NorthWestern Energy
Delivering a Bright Future

April 28, 2023

Mr. Will Rosquist
Administrator, Regulatory Division
Montana Public Service Commission
1701 Prospect Avenue
PO Box 202601
Helena, MT 59620-2601

RE: Docket No. 2022.11.102
NorthWestern Energy's 2023 Integrated Resource Plan

Dear Mr. Rosquist:

In compliance with the *Default Electric Supplier Procurement Guidelines* previously contained in the Montana Public Service Commission's ("Commission") rules, NorthWestern Energy ("NorthWestern") submits its 2023 Integrated Resource Plan ("IRP"). The IRP is organized into two volumes. Volume 1 contains the core requirements, portfolio scenarios, and conclusions. Volume 2 provides additional information and documentation. An electronic version of the IRP has been made available to the public on NorthWestern's website at:
Electric Supply Planning | NorthWestern Energy.

NorthWestern's employee responsible for answering inquiries from Utility Staff about the IRP is:

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Along with Steve Schmitt, Glenda Gibson, and Ann Hill, please add Tracy Killoy to the official service list in this docket to receive copies of all documents. NorthWestern also requests that all electronic correspondence related to this filing be sent to tracy.killoy@northwestern.com.

Sincerely,

Cyndee Fang

Cyndee Fang
Vice President, Regulatory Affairs

Enclosures
cc: Montana Consumer Counsel

NORTHWESTERN ENERGY'S

MONTANA INTEGRATED RESOURCE PLAN 2023

NorthWestern Energy

Delivering a Bright Future

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1. Executive Summary

1.1. Overview of the NorthWestern Energy 2023 Montana IRP

NorthWestern Energy's (NorthWestern or Company) 2023 Montana Integrated Resource Plan (IRP or Plan) provides a roadmap to inform the development of an adequate energy supply portfolio for the coming years. The Plan presents an evaluation of different potential generation resource portfolios that would meet the needs of our Montana electric customers reliably, safely, and affordably over a twenty-year time horizon. This process involves the assembly and analysis of a wide range of data on loads, prices, and resource performance, along with technical information on resource costs and capabilities. All references to NorthWestern assets and customers are intended to reflect those customers and assets in Montana, unless otherwise noted.

The Plan is organized into two volumes. Volume 1 contains the core requirements, portfolio scenarios and conclusions. Volume 2 provides additional information and documentation.

The modeling in this Plan analyzes how a variety of generation resource portfolios might perform across a range of future conditions. The modeling suggests that the best-fit resources to address our portfolio's needs are flexible natural gas generation and energy storage (pumped hydro). These resources are best suited to address the characteristics of our portfolio generally being energy long and capacity short. The economics and longer duration characteristics of these resources were selected over short-duration resources like batteries.

However, regardless of what the modeling indicates, an all type competitive solicitation process, overseen by a third party will be utilized for resource selection to address the needs identified in this Plan. Capacity shortfalls, overreliance on markets, and insufficient flexible generation will be what our next Request For Proposal (RFP) addresses, not the best-fit resources identified.

Resource planning requires the consideration of information about the future, meaning it must consider information that is not known with certainty — including forecasts of prices and electric loads — and incorporates assumptions about the costs and characteristics of different factors, such as generating technologies (among other things). The Plan should be considered a snapshot of best available information at the time of filing. Unforeseen events or circumstances that occur after the Plan's filing are outside the scope of this Plan and may result in changes from the content contained herein. Accordingly, the Plan does not result in specific decisions about new resources for addition to NorthWestern's generation portfolio.[1] Instead, the Plan provides information about the system's likely future needs under different conditions and evaluates various resource types based on their generic costs and characteristics. The Plan thus serves as a useful foundation to evaluate, rather than prescribe, future resource determinations, which would necessarily require more specific information. NorthWestern remains flexible and responsive as the future unfolds and will conduct necessary reassessments when pursuing options identified in this Plan that are capable of meeting our customers' needs reliably, affordably, and safely.

Over the past 100 years, NorthWestern has maintained its commitment to provide customers with reliable and affordable electric and natural gas service while also being good stewards of the environment. NorthWestern has responded to climate change, its implications, and risks, by increasing our environmental sustainability efforts and our access to clean energy resources. NorthWestern's current mix of resources provides 59% of energy generation from carbon-free resources. NorthWestern also is committed to achieving net-zero emissions by 2050.[2] This Plan provides a long-term view for meeting NorthWestern's supply needs in an affordable and reliable way while also considering NorthWestern's goal of net-zero by 2050.

During the planning cycle NorthWestern conducted 8 meetings with the Electrical Technical Advisory Committee (ETAC) to solicit valuable feedback from Montana stakeholders. NorthWestern also researched and evaluated multiple factors influencing the power sector in the Pacific Northwest that are outlined in the Plan. This Plan describes how the landscape is evolving and how NorthWestern will continue to provide service to our Montana customers while balancing reliability, affordability, and sustainability.

The major identified risk for customers, consistent with previous Plans, is an overreliance on an uncertain market to address our critical capacity needs. In fact, recent real world examples indicate that it is becoming increasingly risky in terms of customer affordability and reliability. Also, regional resource reliability requirements are emphasizing that each utility must be able to have peak resource sufficiency and also include a reserve margin. Reliance on short-term market purchases is insufficient to meet this requirement.

Themes outlined in this Plan include the following:

- Balancing reliability, affordability, and sustainability.
- Achieving short-term resource adequacy with the completion of the Yellowstone County Generating Station (YCGS), and the acquisition of additional capacity from the Colstrip power plant.
- Participating in the Western Resource Adequacy Program (WRAP) for reliability and regional coordination.
- Market assessments and impacts of joining an organized market.
- Evaluating our overall capacity and energy position from 2023-2042. Filling gaps left by retirements, undeveloped qualifying facilities (QF), and firming the portfolio with long-term capacity.
- Alignment of our net-zero emissions goal by 2050.
- Key risks and impacts associated with the early retirement of Colstrip Units 3 and 4 (Colstrip) including Available Transmission Capacity (ATC) results and energy supply capacity impacts.
- Transmission import restrictions and on-system transmission limitations.

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[1] Such decisions about specific resource selections would only result following the analysis of detailed and specific information on the candidate resources. These are typically received in response to an RFP but may also arise through unforeseen opportunities or offers.

[2] https://northwesternenergy.com/clean-energy/net-zero-by-2050

1.2. NorthWestern's Need for Additional Capacity

Resource adequacy is a top priority of NorthWestern in order to continue to provide reliable energy service at the most cost-effective rates for our customers. Currently, NorthWestern does not have adequate supply resources to fully serve peak loads throughout the year. Due to the deficiency of power supply during peak demand, NorthWestern regularly relies on imported energy purchases to meet demand. Regionally, the Pacific Northwest is facing tight supply conditions which are expected to persist with projected coal retirements and a lack of adequate replacement power capacity resources. NorthWestern cannot count on continued energy imports to serve our customers reliably during peak demand given the risk of declining capacity generation in the region. An adequate portfolio requires that NorthWestern customers become less reliant on volatile and uncertain energy purchases and provides protection against transmission congestion which limits import availability.

A key component of the strategy to achieve resource adequacy is the completion of the YCGS and the January 2026 addition of the 222-megawatt (MW) share of Colstrip. Once completed, YCGS will provide approximately 170 MW of fast-ramping and reliable generation capacity. The flexibility offered from YCGS's internal combustion engines will allow greater balancing of load with supply in a portfolio that includes 455 MW of intermittent wind serving 1,200 MW of retail load. Due to NorthWestern's large amount of wind, YCGS will be required to be very flexible to balance for variable generation and to provide critical supply capacity and transmission system support during times of system stress.

Figures 1-1 and 1-2 below show NorthWestern's supply portfolio relative to forecast peak load, for the next 20 years. Figure 1-1 presents the capacity position for the winter season and Figure 1-2 shows the summer position, using Effective Load Carrying Capability (ELCC) values under the WRAP[3] . Common to both figures is the addition of YCGS in 2024 and the acquisition of Avista's 15% ownership of Colstrip Units 3 & 4 in 2026. The figures show that even with YCGS online and additional Colstrip capacity, NorthWestern has a capacity deficit early in the planning period in the winter season. Then, the system is sufficient for several years but begins to see larger deficits in the 2030s resulting from term-capacity contracts that expire. The challenges associated with adding supply resources mean NorthWestern must continue taking additional actions to achieve longer-term resource adequacy. Achieving resource adequacy requires adding resources that are available during peak load hours. Variable energy resources (VERs) that lack storage capacity, such as wind and solar, cannot be relied upon to solve capacity issues during stagnant wind or low solar conditions. This is why a diverse and flexible resource portfolio is important and why proper resource capacity accreditation is critical to the planning process.

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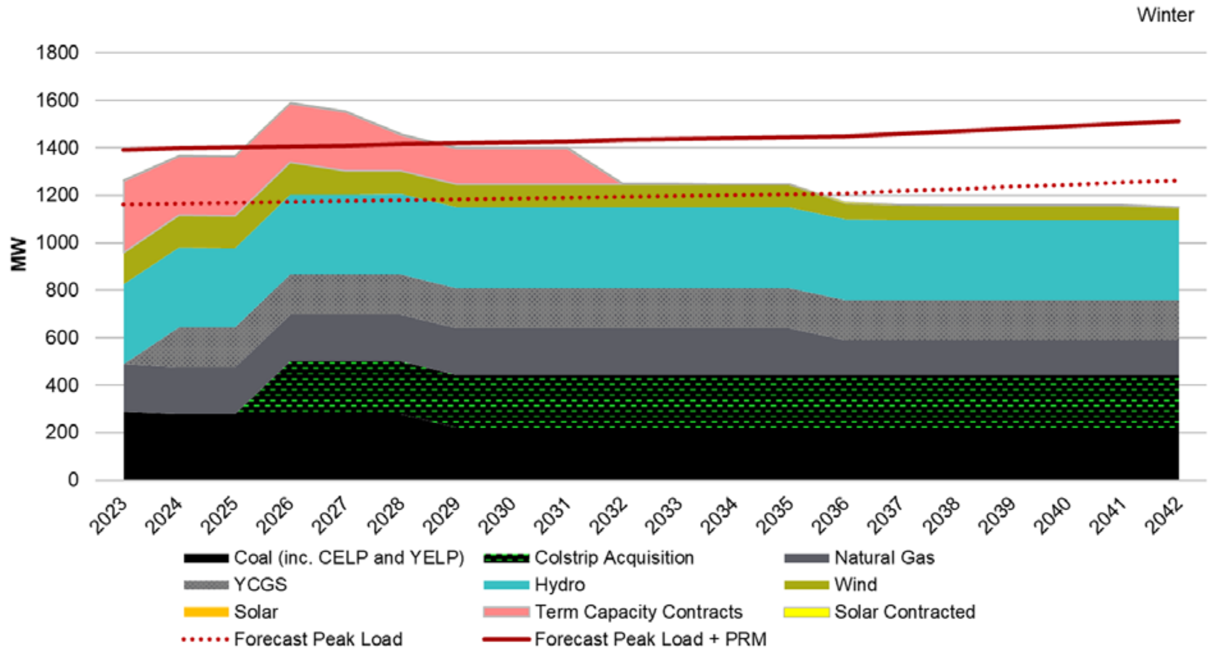
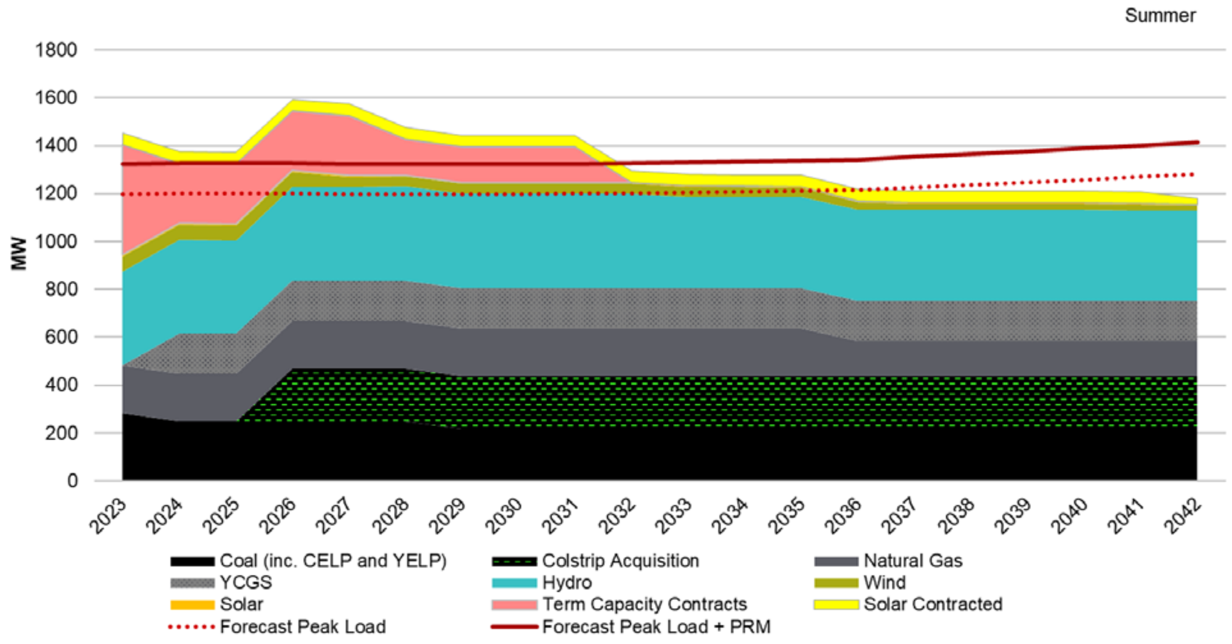
[3] The WRAP ELCC values used in this document are best available values but should be considered provisional and subject to change.

Figure 1-1. NorthWestern's Capacity Position with Current Owned and Contracted Resources and Yellowstone County Generating Station (YCGS) – Winter WRAP ELCCs



Seasonal differences are visible between the winter and summer views, both in peak load and resource contribution values. For example, the solar contribution in winter is dwarfed by other resources and not evident, while wind generation is higher in winter. Other resources such as coal, natural gas, and energy contracts do not exhibit seasonal change.

Figure 1-2. NorthWestern's Capacity Position with Current Owned and Contracted Resources and Yellowstone County Generating Station (YCGS) - Summer WRAP ELCCs



1.3. Supply Uncertainty, Load and Transmission

Qualifying Facilities (QFs) under the Public Utility Regulatory Policies Act of 1978 (PURPA) increase the supply uncertainty for NorthWestern. Currently, NorthWestern has either signed contracts or received interest from several QFs in various stages of development (see Chapter 8). However, historically many QFs in the queue do not achieve commercial operation, and there is no guarantee that some or any of the projects in the current QF queue will end up as resources in NorthWestern's portfolio. Additional supply uncertainty is also associated with the future operations of Colstrip after 2029, which would have a large effect on NorthWestern's capacity position. An early closure of Colstrip would not only increase the existing supply deficit but would also create a need for significant transmission upgrades as explained in Chapter 8. QF and Colstrip risks are central to the modeling used in this Plan and are described in more detail in Chapter 8. The modeling shows that a combination of energy storage and natural gas capacity may be the resources that could best meet customers' needs for resource gaps caused by undeveloped QFs or an early retirement of Colstrip.

Retail load in NorthWestern's territory is forecast to grow at an annual average rate of 0.3% (Figure 1-3). Peak demand is projected to increase at 0.3% in the summer and 0.4% in the winter. Figure 1-3 also shows the savings from demand side management (DSM) and net energy metering (NEM) that are expected to reduce NorthWestern's peak load obligation.

Figure 1-3. Impact of DSM and NEM on Load Forecast, Including Transmission Losses (Annual Megawatt Hours - MWh)

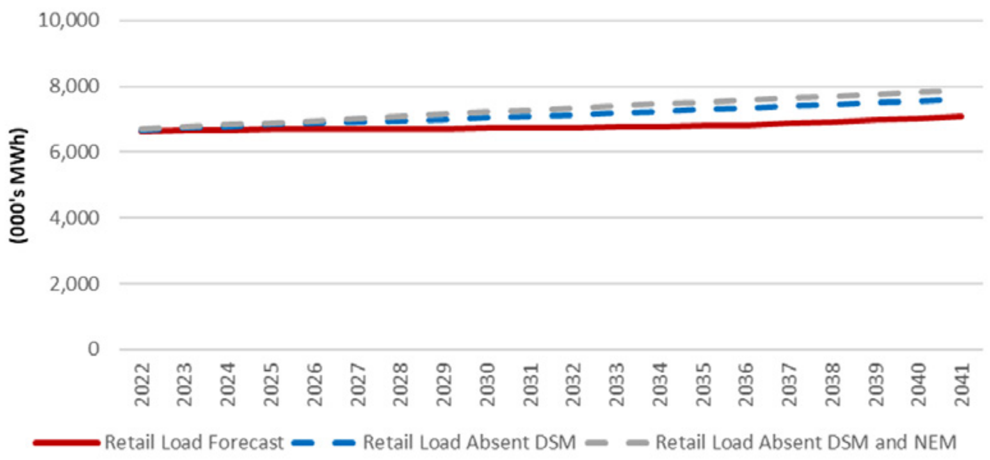
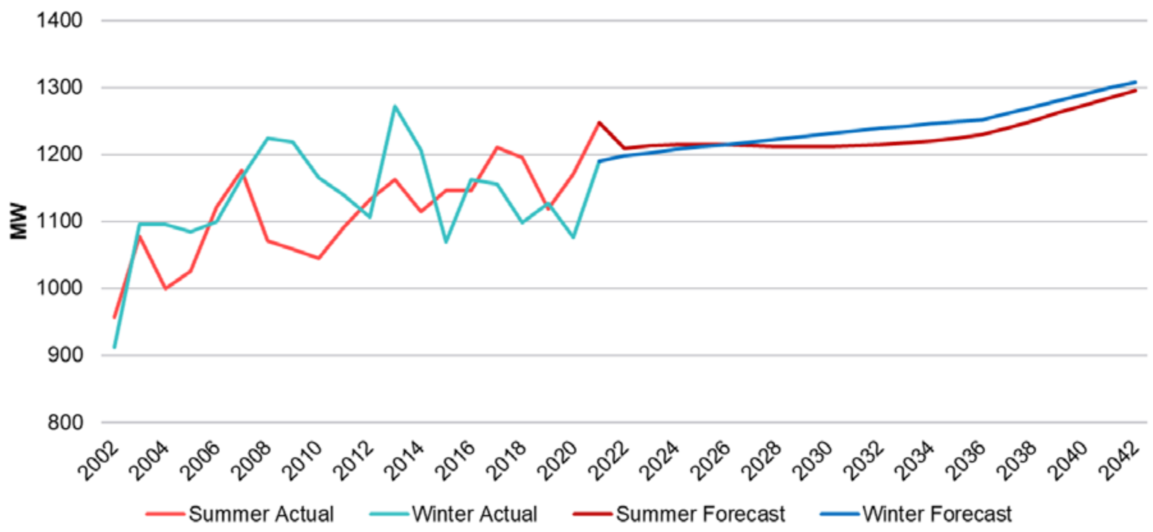


Figure 1-4 shows a twenty-year history of observed peak seasonal load, and a twenty-year forecast. NorthWestern's annual peak load hour has occurred in the summer in recent years. However, load forecasts project more frequent winter peaks in the future. Details on retail load can be found in Chapter 6.

Figure 1-4. Observed and Forecast Peak Retail Load by Season



NorthWestern's transmission system comprises approximately 6,900 miles of lines in Montana. This transmission system provides vital service within Montana, and connects NorthWestern with Montana's neighboring regional markets. Load growth in recent years has created capacity constraints in the Billings, Butte, and South of Great Falls areas that will require capital improvements soon to maintain reliable service. South of Great Falls has also been impacted by significant additions of variable energy recourses while the Billings area has been impacted by both load growth and traditional generation retirements. If Colstrip is retired, the transmission network will require additional upgrades to maintain reliability. Details are described in Chapter 7.

1.4. Regional Outlook and Coordination

NorthWestern is taking steps to reach resource adequacy through the WRAP. As a founding member of the WRAP, NorthWestern is participating in the program development and timelines in coordination with other energy companies in the region (Figure 1-5). WRAP requirements will become binding as early as 2025. The WRAP is a tool for energy companies to use to maintain reliable service. It is a cooperative approach addressing the changing energy generation resource mix and expanding energy load growth in the West. The WRAP will provide a standard approach to calculate resource adequacy across the region to ensure an accurate and transparent evaluation of the resources among participating utilities. Once fully implemented the standardization and coordination improvements are expected to enhance efficiency and cost effectiveness in utility planning and operations.

Figure 1-5. WRAP Timeline

NorthWestern became a participant in the Western Energy Imbalance Market (W-EIM) in June of 2021. The W-EIM is a real-time market providing energy prices on five- and fifteen-minute intervals and dispatch of participating resources on five-minute intervals. Participation in the W-EIM allows NorthWestern the ability to better manage energy generation from flexible resources and benefit from real-time marketing. The W-EIM does not provide nor is a replacement for capacity resources and does not contribute to long -term Resource Adequacy.

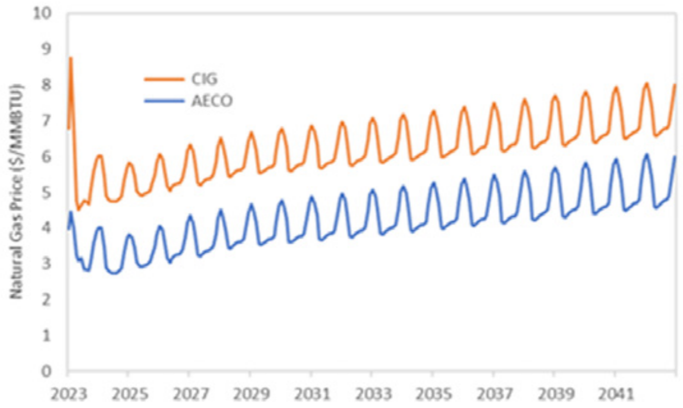
NorthWestern is currently evaluating potential benefits of joining a day-ahead market. Two day-ahead markets are under development in the West and could provide additional benefits for NorthWestern by committing resources a day in advance in coordination with other day-ahead market resources across the region. NorthWestern will not commit to joining a day-ahead market until it has sufficient information on the market designs and the intention of neighboring utilities to join a market.

Newer energy market structures, such as W-EIM and WRAP impose Resource Sufficiency (RS) tests to ensure energy companies do not create an undue burden on the overall system. Generally, a portfolio that is primarily resource sufficient and that has ramping capability to cover potential load ramps will pass W-EIM RS tests and maintain W-EIM participation. Failure to pass W-EIM RS tests can lead to freezing transfers in the direction of failure (i.e., if short, a participant could not increase imports). W-EIM participants are also subject to charges when failing to follow schedules set in the W-EIM. Upon the start of the binding phase, WRAP will also assess deficiency charges if an entity fails to demonstrate sufficient resources. NorthWestern is operating in the W-EIM currently and is a party in the ongoing WRAP rollout. The associated RS requirements mean that NorthWestern needs to secure adequate and flexible capacity ahead of time to participate in the benefits of these markets and avoid penalties. This capacity could come from Company-owned resources, energy contracts, and/or market purchases.

The energy transition from fossil fuel resources to variable generation in the form of wind and solar is changing market dynamics in the U.S. and especially the West where renewable growth is much higher than other parts of the country. VERs have little to zero marginal cost meaning that high levels of wind or solar generation push average market prices down over time, but large ramps in VER generation lead to higher volatility in market prices. The variable nature of VERs requires other dispatchable resources to balance over- and under-generation.

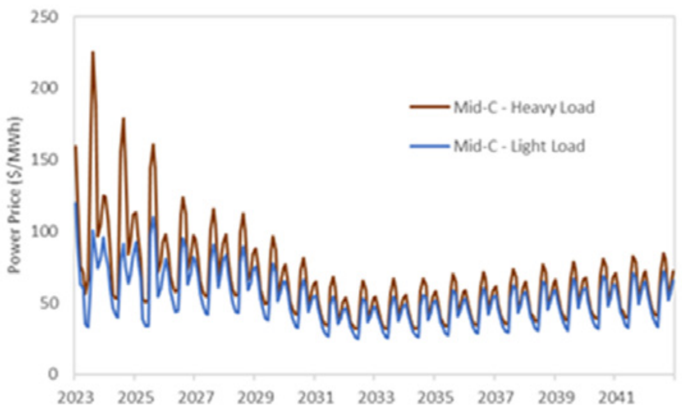
Natural gas price forecasts for the Alberta Energy Company (AECO) and Colorado Interstate Gas (CIG) trading hubs are shown in Figure 1-6. The forecast uses prices from futures trading for the next four years at AECO followed with a 2% annual increase. The basis between natural gas prices at CIG and AECO have shown CIG to be $2 higher than AECO on average. The basis between CIG and AECO is projected to remain at $2.

Figure 1-6. **AECO and CIG Natural Gas Price Forecast**



Power prices at the Mid-Columbia trading hub (Mid-C) start high and drop quickly in the near-term as observed in the future market prices for power at Mid-C (Figure 1-7). The mid-term prices decline with renewable growth until the early part of the 2030s. In the long-term, prices rise gradually mainly due to carbon price projections in California and Washington.

Figure 1-7. **Price Forecasts for Mid-C Power**



NorthWestern evaluated future supply options under various future scenarios for Colstrip and QF builds using Ascend Analytics' (Ascend) PowerSIMM™ model. This Plan found that energy storage (pumped-hydro and battery storage) and flexible natural gas resources (combustion turbines and internal combustion engines) provide the optimal mix of supply to achieve resource adequacy. Key findings from the modeling include:

1. Energy storage (pumped-hydro and battery storage) and flexible natural gas resources (combustion turbines and internal combustion engines) provide the optimal mix of supply to achieve resource adequacy.
2. Early Colstrip retirement scenarios increase overall cost due to the need to replace the lost capacity with new resources.
3. In the 2030s, NorthWestern's long energy position will decline, making wind power better suited to serve load as judged by its projected cost.

As stated earlier in this section, NorthWestern needs to procure more capacity to achieve a resource adequate portfolio. Given the uncertainty at this time, NorthWestern will follow the action plan outlined below and described in more detail in Chapter 10.

1. Participate in the ongoing development of the WRAP
2. Bring YCGS to commercial operation
3. Monitor the need for a competitive solicitation, evaluate Opportunity Resources, and track QF development while maintaining a resource adequate portfolio
4. Evaluate the future of Colstrip operations
5. Monitor the acceleration of "electrification"
6. Evaluate the development of new technologies
7. Issue an RFP for DSM resources and evaluate results
8. Study the most effective transmission expansion opportunities in coordination with NorthWestern's Transmission department.

2. Planning and Process History

2.1. Montana Planning Requirements

NorthWestern's electricity supply resource planning and acquisition are governed by Montana's Integrated Least-Cost Resource Planning and Acquisition Act (Act) found at Mont. Code Ann. § 69-3-1201 - § 69-3-1209. Prior to January 2023, the Montana Public Service Commission's (MPSC) resource planning and acquisition rules applicable to NorthWestern were the Default Electric Supplier Procurement Guidelines found at Admin. R. Mont. 38.5.8201- 8204. Volume 2, Appendix D of this Plan lists the Montana statutes in the Act and the pre-2023 rules. NorthWestern developed this Plan from 2021-2023 following the requirements and guidelines in the pre-2023 rules.[4] A checklist of the applicable statutory and regulatory requirements and the location(s) where they are addressed in this Plan is provided in Volume 2, section 2.1.

Under the Act and the rules, NorthWestern files an integrated least-cost plan every three years. The Plan primarily includes an evaluation of cost-effective means to provide reliable service, an assessment of the need for additional resources, and the process for acquiring resources. The assessment and evaluation are supported in the Plan with data regarding observed and forecast electric demand, resource capacities, and a representation of the costs and benefits for increasing renewable and demand side-resources.

2.2. NorthWestern Resource Planning – Historical Context

2.2.1. The 2019 Plan

NorthWestern filed its 2019 Plan with the MPSC in August 2019. The MPSC provided comments in July 2020. Responsive to those comments, NorthWestern filed a Supplement to the 2019 Plan in December 2020. The key findings of the 2019 Plan included:

1. The Pacific Northwest faces an increasing probability of near-term deficits in its power supply during peak load conditions that is likely to continue without increased investments in new capacity.
2. NorthWestern had a capacity deficit of 645 MW short of meeting standard resource adequacy targets. NorthWestern emphasized it should seek generation to bridge the gap closer to the Planning Reserve Margin (PRM) of 16%.
3. NorthWestern analyzed a variety of resource portfolios to determine the least cost portfolio. The least cost portfolio contained a mix of 4-hour batteries and natural gas reciprocating internal combustion engine (RICE) units. Generally, lower carbon-emitting portfolios were found to have higher cost.
4. NorthWestern joined the W-EIM and anticipates a maturing market is likely to lead eventually to a full Regional Transmission Organization (RTO) in our service territory.
5. NorthWestern's 500 kilovolt (kV) transmission line plays an important part in transmitting Colstrip's power and also importing power into Montana. Our overall transmission availability presents an increasing risk that Montana will not be able to import adequate power during peak load events.

2.2.2. 2019 Plan Feedback

The MPSC provided comments and recommendations on the 2019 Plan. NorthWestern addressed many of the comments and recommendations in the 2020 Supplement, and has further considered the comments and recommendations in developing this Plan. The MPSC's comments and NorthWestern's responses are listed below.

- NorthWestern should clarify: whether its objective is to solicit offers that enable it to evaluate and/or acquire a diverse mix of power capacity resources, how its solicitations include a diverse set of resources, the meaning of "short-term" and "long-term" resources, the meaning of "ride-through capacity", and the applicability of the 16% PRM. NorthWestern should state how ELCC values are derived and consider other ELCC methodologies, regional and monthly values.
  - NorthWestern's objective is to become resource adequate to provide reliable service to its customers. This includes an "all of the above" strategy for resource acquisition including pursuing Opportunity Resources as they become available, running RFPs for long-term capacity, securing short-term contract resources, and participating in QF negotiations. All of this will be done in accordance with least-cost planning principles. In the Glossary in Appendix B, NorthWestern defined "short-term resource", "long-term resource" and "ride-through capacity".
  - NorthWestern explained in the 2020 Supplement that the PRM of 16% is consistent with North American Electric Reliability Corporation (NERC) recommendations for the Western Electricity Coordinating Council (WECC) and is also comparable to other utilities. This 2023 Plan also presents and utilizes WRAP PRM values.
  - The historic ELCCs by resource type were derived originally by Energy + Environmental Economics (E3) and confirmed by Ascend's modeling. More detail on ELCC analysis is contained in Chapter 8 of this Plan.
  - NorthWestern provided the historic ELCC values used in the 2023 Plan in tables and figures (e.g., Volume 2, Table 6-1). Both historic and initial WRAP ELCC values are contained in the supporting electronically submitted files.
- "In future plans, NorthWestern should describe key modeling assumptions with more transparency and specificity."
  - Section 8 of this Plan details the key modeling assumptions associated with the PowerSimm studies.
- "In future plans, NorthWestern should more thoroughly describe and support near-term resource solicitation strategies."
  - This Plan evaluates NorthWestern's capacity position under multiple load, ELCC, and portfolio composition scenarios. To the extent that it results in a resource solicitation, a formal RFP will be issued that describes the need and acquisition strategy. Section 6.3 discusses NorthWestern's resource acquisitions for both YCGS and additional Colstrip capacity. Both of these energy resources serve near- and long-term capacity needs.
- "In future plans NorthWestern should consider a broader, seasonal approach to evaluating its capacity needs."
  - This Plan explores and presents capacity for both winter and summer seasons, under both historical and WRAP ELCC methodologies. As NorthWestern's load exhibits peaks in both winter and summer, these are the most relevant seasons for evaluating resource sufficiency against our peak load forecast.
- "For future Plans, NorthWestern should consider defining a paired resource option or, alternatively, define monthly capacity contributions for individual resources and monthly capacity requirements. In addition, NorthWestern should consider the use of system-specific or regional ELCC-based capacity contributions."
  - NorthWestern has been a key member in the development of the WRAP which defines monthly capacity contributions, based on a regional footprint. WRAP is not yet finalized so this Plan utilizes averaged WRAP capacities for the winter and summer months. It is anticipated that future Plans will present the more granular monthly capacity views once WRAP is fully functional.

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[4] In January 2023, the MPSC adopted new rules found at Admin. R. Mont. 38.5.2020 -38.5.2025.

- The cost and risk of different market-procured capacity resources of variable lengths is not addressed in the modeling.
  - ↳ NorthWestern has included figures and tables in this Plan that show the assumptions utilized in the Plan's calculations and modeling scenarios. These include solar and wind resources. Please see Chapters 6 and 8 of the 2023 IRP as well as Volume 2, Chapter 6.
- The PowerSimm modeling for the 2019 Plan did not adequately consider alternative scenarios in which wind and solar resources contribute relatively more to NorthWestern's capacity needs.
  - ↳ This Plan utilizes the WRAP accreditation values for all resource types which are included in Volume 2.
- The cost modeling for the 2019 Plan did not evaluate a scenario that combined the "lower cost" cost curves for wind, solar PV, and Li-ion batteries with higher natural gas costs, coupled with the presumption of membership in an RTO (which, as discussed above, could potentially result in higher capacity credit for Montana wind and solar resources).
  - ↳ This Plan includes the "Joint Environmental Group Scenario" that contemplates an early retirement of Colstrip and replacement options consisting of energy storage, wind, and solar. NorthWestern also received revised resource costs from Aion that were coupled with anticipated Inflation Reduction Act (IRA) benefits in the PowerSIMM model. Finally, while potential accreditation effects of joining an RTO have not been evaluated, the Plan does utilize WRAP accreditation values that are similarly increased due to a larger regional footprint.
- The 2019 Plan mistakenly used the base-case gas price curves when attempting to model the high-gas price curves and did not account for the cost of moving gas supply across the system. The Plan was deficient for not analyzing a scenario that combined lower cost curves for VERs, high gas prices, and coupled with the presumption of an RTO. Operation and Maintenance (O&M) for solar resources appears to be higher than National Renewable Energy Laboratory's (NREL) 2019 data suggests.
  - ↳ Most of the 2019 errors were remedied via the 2020 Supplement and NorthWestern expanded its analyses in this Plan.
  - ↳ This Plan includes updated resource cost estimates that reflect anticipated IRA incentives for renewable resources. It also includes sensitivities around high gas and power prices and high load. All of the modeling scenarios are detailed in Chapter 8. The VER types and prices and fuel costs used in modeling are presented there as well. NorthWestern included a number of sensitivities to the base case model, explained in Chapter 8.
  - ↳ NorthWestern's capacity position under the WRAP is presented in Chapter 6 of this document. While WRAP is not the same as an RTO, there are similar improvements to resource accreditations owing to a larger regional footprint.
- The 2019 Plan does not explain the impact of ancillary services as a result of joining the W-EIM. The next plan should address this. The Plan does not explain whether investments in the transmission system could cost-effectively expand access to market or other supply resources.
  - ↳ The W-EIM requires participating entities to be resource sufficient; therefore, it does not alter NorthWestern's capacity planning needs and need for dispatchable capacity.
  - ↳ NorthWestern continues to make transmission improvements, but as noted in the 2020 Supplement, transmission improvements alone are not sufficient to attain resource adequacy. Transmission improvements might increase NorthWestern's line transfer capability to import from outside its Balancing Authority, but would not ensure the actual availability or economy of energy.
- Program lives of DSM measures should be 20 years to be equal to most QF resources. An updated DSM cost analysis should be included in future plans and included in any RFP.
  - ↳ NorthWestern provided details regarding its DSM activities, costs, and estimated potential capacity contributions to meet peak load in the 2020 Supplement.
  - ↳ This Plan provides additional details on DSM efforts, contributions, and costs in Chapter 5. DSM is incorporated in the load forecasts as well.

2.3. Results of the 2020 RFP

To implement the Action Plan from the 2019 Plan, NorthWestern conducted an all-resource competitive solicitation RFP, administered by Aion. The RFP sought 280 MW of capacity resources to partially address a power capacity deficit of up to 645 MW[5]. The RFP resulted in the selection of a portfolio of three resources: a 5-year market purchase agreement for 100 MW of capacity and energy products from Powerex Corp., the Beartooth Battery (50 MW of storage for up to 4 hours)[6], and YCGS (a 175-MW RICE natural gas plant). NorthWestern executed contracts for all three resources, with the Beartooth Battery application ultimately being dismissed by the MPSC. The market purchase agreement is currently active, with a delivery term of January 1, 2023 through December 31, 2027. YCGS is currently under construction with a commercial operation date anticipated in 2024. Finally, the WRAP program increases the accreditation of many resources in NorthWestern's portfolio, which results in capacity improvements.

2.4. ETAC's Role In The Planning Process

NorthWestern is "required to maintain a broad-based advisory committee to review, evaluate, and make recommendations on technical, economic, and policy issues related to a utility's electricity system." § 69-3-1208, MCA. NorthWestern is also required to hold at least two public meetings when developing a plan. §6 9-3-1205, MCA. In an effort to be transparent in the planning process, NorthWestern opened all ETAC meetings to the public, which allowed any interested stakeholder to participate with ETAC as an equal party. For this planning cycle, ETAC included representatives from Montana Department of Environmental Quality (MTDEQ), Missoula County, Friends of 2 Rivers, Renewable Northwest, and other groups. The following are some highlights of the stakeholder process utilized for the development of the Plan:

- NorthWestern engaged Ascend to facilitate ETAC meetings. The meetings included frequent updates to the Plan as it developed, an in-depth look at PowerSIMM modeling software, and opportunity for stakeholders to provide feedback that helped guide the development of the Plan.
- NorthWestern held 8 ETAC meetings to update members on the planning process and request feedback on planning direction, including sensitivity modeling suggestions.
- ETAC and the public were given time to provide comments on the draft plan.
- ETAC members provided feedback on the modeling inputs and suggested a scenario for no carbon additions in the portfolio.

2.5. Resource Acquisition Strategy

NorthWestern seeks to be resource adequate to provide reliable service to customers. As such, NorthWestern plans to meet its expected peak load plus a planning reserve margin. If the capacity accreditation[7] of the entire portfolio of generating assets does not meet the planning reserve margin, then NorthWestern will seek to acquire new generating resources (or short-term capacity contracts) in its portfolio. NorthWestern may acquire new resources through an RFP process, an Opportunity Resource acquisition, or through the PURPA QF process.

2.5.1. Competitive Solicitations of Proposals for Resource Acquisitions[8]

A competitive solicitation process (via RFP) may result in the acquisition of the types of resources identified in the modeling conducted for this Plan. However, it is important to note that the modeling work in this Plan used assumed inputs for hypothetical future resources. Resources submitted as proposals in response to a competitive solicitation may differ from the hypothetical resources used in the Plan.

NorthWestern will evaluate the need to solicit proposals for new generation resources if any of a variety of factors significantly change its current capacity position (as discussed in Chapter 6). Assuming the resources in our Base Case scenario develop in the expected timelines, the earliest that NorthWestern would issue an RFP would be mid-2024.

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[5] The 645 MW deficit was derived including the 16% Planning Reserve Margin (PRM).

[6] The MPSC dismissed NorthWestern's application for approval of the Beartooth Battery in Docket No. 2021.11.132.

[7] As of the writing of this Plan, the ELCC values of NorthWestern's resources under the WRAP are not finalized.

[8] See Volume 2 Chapter 2 for a detailed explanation of the RFP Process.

The RFP process is a lengthy and can take years from the request phase to actual commercial operations of new resource. As an example, the YCGS plant stemmed from a 2020 RFP and is expected to begin generating in 2024. Likewise, if NorthWestern issues an RFP in 2024, any procured resource would likely take a minimum of four to six years to achieve commercial operation. In contrast, securing resources through the opportunity resources path is faster and has recently been instrumental to bolstering NorthWestern's resource portfolio. NorthWestern's hydro assets and the Avista share of Colstrip were both secured as opportunity resources.

2.5.2. Opportunity Resources

The Montana Legislature adopted a policy of encouraging energy provider acquisition of resources through competitive solicitations. § 69-3-1202(b), MCA. However, competitive solicitations are not applicable to "opportunity resources." Opportunity resources are those resources necessary to meet a need demonstrated in the Plan that is either new or existing and that remains unknown as to its availability for purchase until an opportunity to purchase arises. See § 69-3-1207(6), MCA. Therefore, Montana law does not preclude acquisition of opportunity resources outside of a competitive solicitation process. Typically, opportunity resources are existing assets that become available for acquisition on short notice and with a short timeframe for transaction completion. Owners of opportunity resources often control the process. NorthWestern evaluates opportunity resources in a manner consistent with the methodologies contained in the most current resource plan to determine if the opportunity resource could fill a portfolio need in an economical manner and result in just and reasonable rates for customers in compliance with Montana law. When evaluating opportunity resources, NorthWestern evaluates the avoided cost, market costs, costs in comparison to the most recent RFP data for resource acquisition, and how the resource contributes to NorthWestern's portfolio need from a power capacity and energy standpoint. If these costs compare favorably NorthWestern may pursue acquisition of the resource.

2.5.3. Qualifying Facilities[9]

Certain power production facilities may meet the criteria to be a QF under PURPA. NorthWestern is obligated to purchase the energy and power capacity from these facilities at its avoided cost. See 18 CFR §§ 292.303 and 292.304. A utility's avoided cost includes all costs to serve customer load that are avoided due to the purchase of energy and/or capacity from the QF. See 18 C.F.R. § 292.101.

For QFs smaller than 3 MW in size, the QF can select from one of the rate options in the Electric Tariff, Schedule No. QF-1 and is paid pursuant to a standardized Power Purchase Agreement (PPA). For QFs greater than 3 MW (up to a maximum of 80 MW) NorthWestern pays the QF avoided cost of energy rates calculated at the time of delivery, unless NorthWestern and the QF agree to a different rate. See ARM 38.5.1905. NorthWestern's current method for calculating a rate at the time of delivery is to use the real-time price of energy at the Location Marginal Price (LMP) of the generator node. NorthWestern's current method for calculating the avoided cost of capacity includes using the least-cost proxy capacity resource that NorthWestern would build, but for the QF. For more details regarding the methodologies used to calculate avoided cost, please see Vol. II.

2.6. Planning Process In Review

NorthWestern's 2023 IRP covers the constantly evolving planning landscape. It dives into changes that are expected in the near term, and how said changes impact the planning horizon, customer needs and growth, and least-cost potential portfolios. Additionally, it covers different generation resource retirement scenarios, potential pricing structures, and plans to accommodate various changes should they arise in the future.

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[9] See Volume 2 Chapter 2 for a detailed explanation of the QF Process.

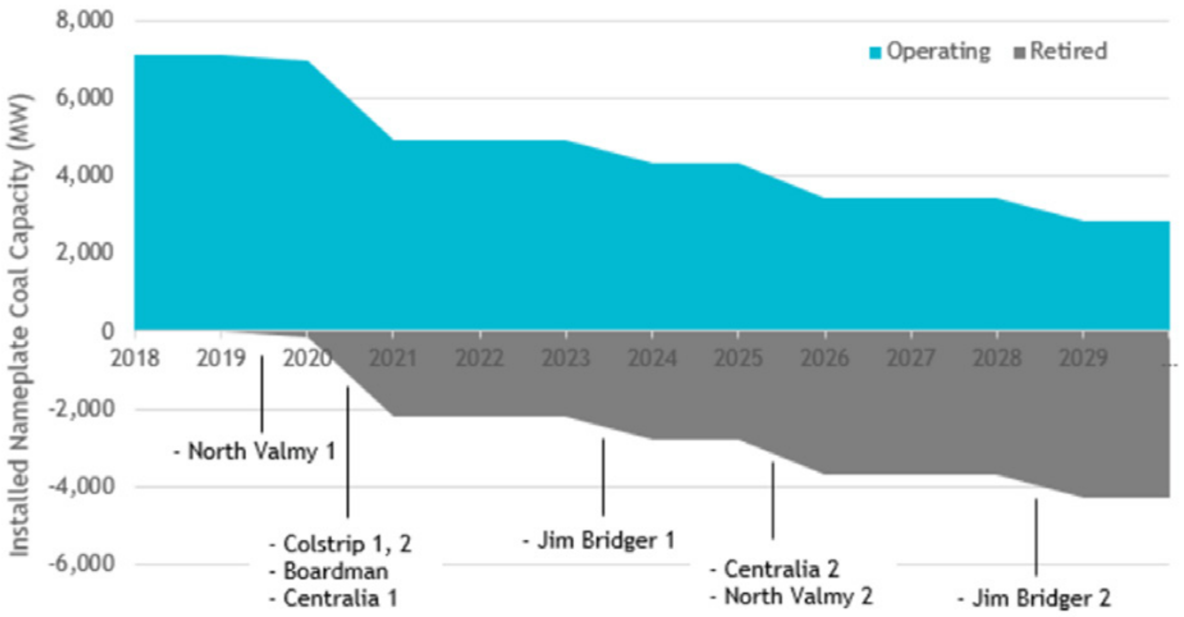
3. Regional Outlook

NorthWestern's system is integrated into the wider Pacific Northwest system. Regional policies affect NorthWestern's operations and ability to import energy to serve customer demand. This section reviews some of the important aspects of the Pacific Northwest power system.

3.1. Regional Power Supply and Demand Outlook

The energy sector is undergoing a transition due to multiple factors driving changes in supply resources, availability and operating characteristics, and resource sufficiency. Coal retirements, increases in wind and solar, and decarbonization policies are among the most important factors contributing to the energy transition. While coal retirements and growth of VERs have been happening across the region for years, the pace and magnitude of change is intensifying, resulting in increased challenges for utilities to plan for and maintain an adequate and reliable power system while accommodating future uncertainty.

Figure 3-1. **Planned Coal Plant Retirements – 2021 NWPCC Power Plan**[10]



Planned coal retirements are shown in Figure 3-1. According to the Northwest Power and Conservation Council (NWPCC), coal retirements will drive capacity from coal down from 5 gigawatts (GW) to 2.4 GW by 2028.[11] While coal traditionally provided reliable, low-cost energy, the carbon emissions from coal-fired generation means coal generation will likely continue to decline for the foreseeable future. NWPCC's most recent resource adequacy assessment of the Pacific Northwest cited coal retirements as a primary driver in Loss-of-Load probability (LOLP) results that exceed their 5% limit beginning in 2021.[12] Replacing lost capacity due to coal retirements will be the major challenge in the region for several years.

Figure 3-2 shows the NWPCC's projected resource additions across the WECC for its unconstrained planning scenario. The NWPCC also ran a scenario with limited natural gas builds resulting in higher growth in wind, solar, and storage.

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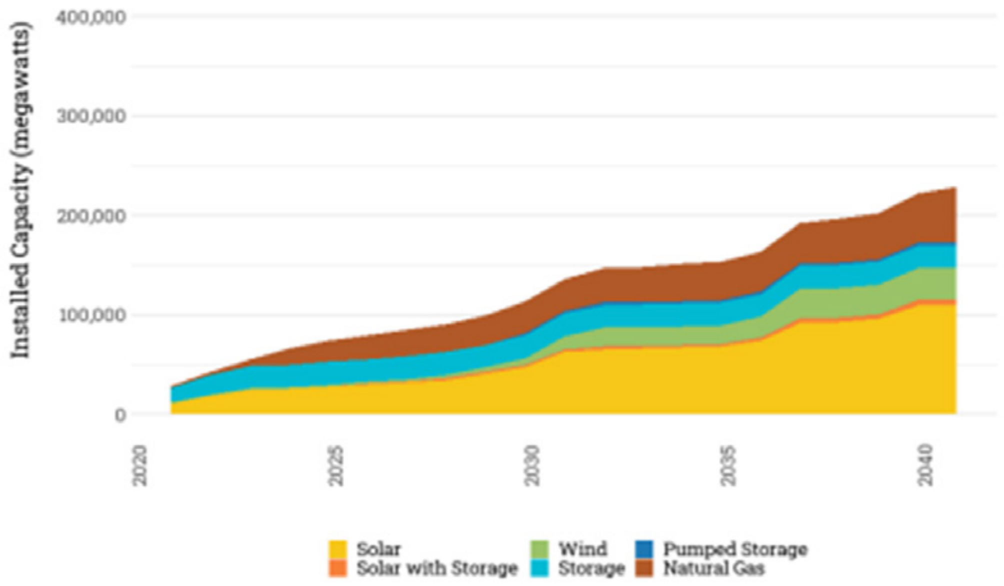
[10] Northwest Power and Conservation Council 2021 Power Plan pg. 61. https://www.nwcouncil.org/fs/17680/2021powerplan_2022-3.pdf

[11] Northwest Power and Conservation Council 2021 Power Plan pg. 61.

[12] Pacific Northwest Power Supply Adequacy Assessment for 2024 (nwcouncil.org).

Figure 3-2. Projected Generation Additions in NWPCC Unconstrained Scenario[13]



VERs, like wind, solar, and battery technology, are frequently proposed as replacements for legacy energy resources such as coal. In fact, the NWPCC recommends acquisition of at least 3,500 MW of renewable resources in the region by 2027.[14] VERs create operational challenges due to their intermittency and uncertainty, which must be balanced with other dispatchable resources. During peak demand hours (e.g., heat waves and cold snaps), VERs may not generate at a level that maintains reliable operations. For example, Figure 3-3 shows an example of wind generation and variability during a day in July of 2022 in NorthWestern's Balancing Authority Area. On this summer day, wind generation was minimal until 15:30, when it ramped up to ~300 MW for ~1.5 hours before declining sharply and oscillating for the rest of the evening hours.

The addition of energy storage resources provides some ability to enhance reliability during peak demand hours but only to the extent allowed by their maximum duration and state of charge at the onset of those hours. Longer duration storage needed to provide ride-through capacity is expensive compared to other dispatchable resource options that offer more flexibility.

Figure 3-3. Total Balancing Authority Wind (MW) – 7/13/2022

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[13] Northwest Power and Conservation Council 2021 Power Plan pg. 73.

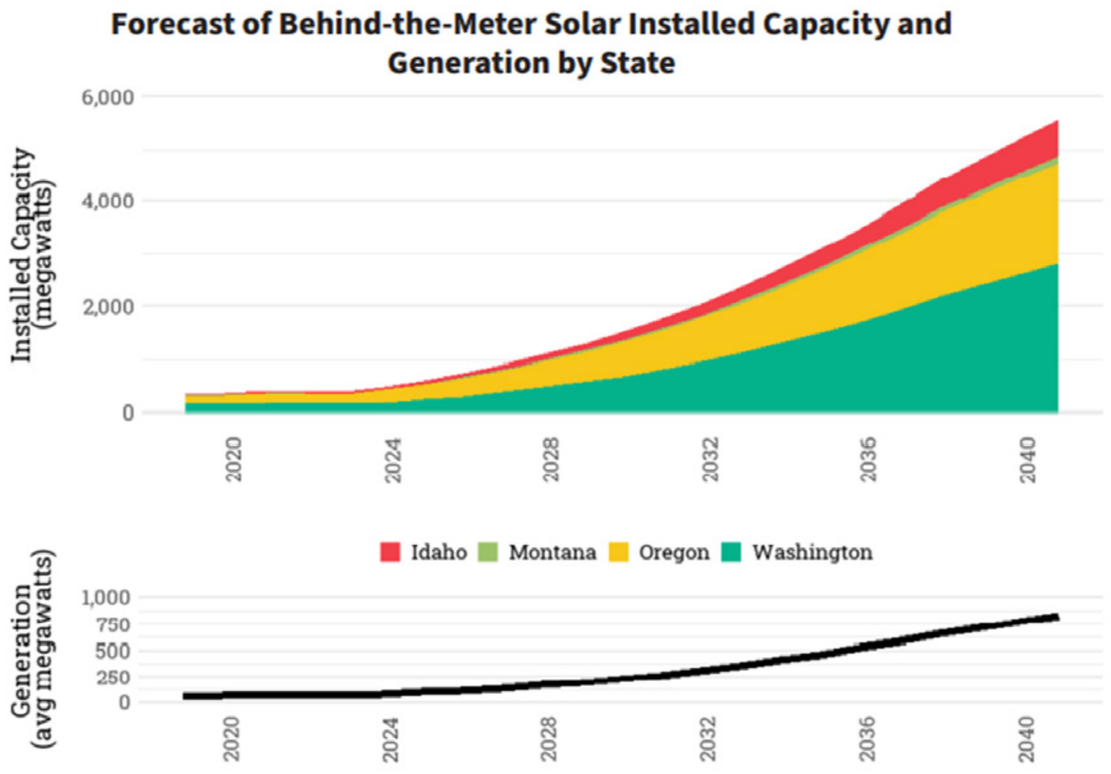
[14] Northwest Power and Conservation Council 2021 Power Plan pg. 46; https://www.nwcouncil.org/fs/17680/2021powerplan_2022-3.pdf.

Along with changes in the region's supply, load demands are also changing. Population growth, building electrification, electric vehicles, demand side management, data centers, and behind-the-meter resources are all expected to affect load growth and consumption patterns in the future. Additionally, cooling degree days for the region have increased in recent years driving higher air-conditioning loads. The NWPCC Power Plan looked at load growth across multiple demand sectors (e.g., residential, commercial, etc.). Averaged together, their medium growth forecasts are approximately 9.5% higher in 2041 than 2021.[15]

NWPCC forecasts strong expansion of behind-the-meter solar (Figure 3-4 below) with Oregon and Washington accounting for ~90% of the buildout (from the four states of ID, MT, OR and WA). Note the relatively minimal buildout forecast in Montana.

NWPCC's Power Plan recommends greater investments in energy efficiency and demand response as part of solution to address regional energy needs. More information on NorthWestern's demand side management programs can be found in Chapter 5.

Figure 3-4. Forecast of Behind-the-Meter Solar[16]



The NWPCC resource adequacy study states a need for flexible supply resources in the region that can support ramping needs and adjust output.[17] Flexible resources are often termed dispatchable resources. As VERs such as wind and solar continue to be built, driven by economics and policy, the region also needs reliable dispatchable capacity to balance the system and support resource adequacy. Dispatchable capacity can provide multiple services including frequency response (timeframe: seconds), peaking capability (timeframe: hours), and contingency reserves. The added services from dispatchable resources enhance system reliability and allow higher integration of VERs. The North American Reliability Corporation (NERC) 2022 Summer Reliability Assessment[18] notes that energy risks exist in the region as the resource mix changes and that dispatchable resources are relied on "to support balancing the increasingly weather-dependent load with the variable energy generation within the resource mix." NERC assessed the summer risk for the western states as "elevated", with the potential for

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[15] Northwest Power and Conservation Council 2021 Power Plan, pg. 24.

[16] 2021powerplan_2022-3.pdf (nwcouncil.org), pg. 25.

[17] 2021powerplan_2022-3.pdf (nwcouncil.org), pg. 111.

[18] 2022 SRA Draft (nerc.com).

insufficient operating reserves in above normal conditions (Figure 3-5). The assessment also cites risks of load interruption stemming from the growing reliance on transfers within the Western Interconnection, coupled with declining resource capacity in multiple adjacent areas.

Figure 3-5. NERC's Assigned 2022 Summer Reliability Risk by Region[19]

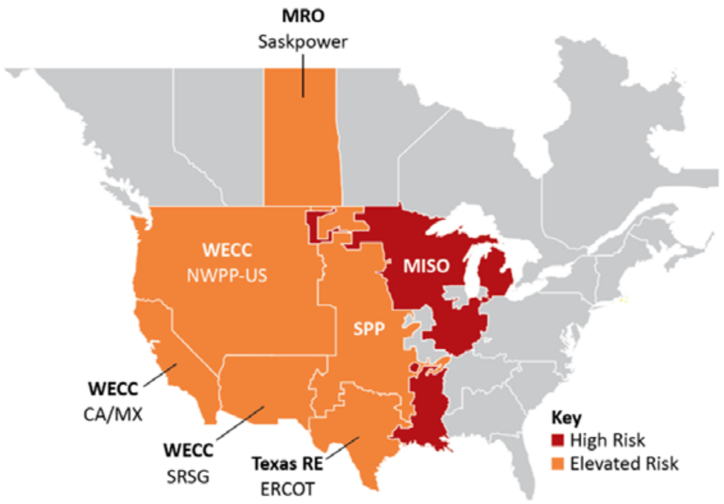

Figure 1: Summer Reliability Risk Area Summary

Seasonal Risk Assessment Summary	
High	Potential for insufficient operating reserves in normal peak conditions
Elevated	Potential for insufficient operating reserves in above-normal conditions
Low	Sufficient operating reserves expected

3.2. The Changing Regional Power Supply – Impacts on Market Prices and Resource Adequacy

The energy transition from dispatchable fossil fuel generation to weather-driven renewable generation is causing a shift in market fundamentals leading to downward pressure on average wholesale energy prices while increasing price volatility. VER resources can displace more expensive natural gas generation during time periods when the variable resources are generating, but balancing resources are still required to be available at all times. Balancing reserves are typically provided by traditional (non-VER) resources. The trend will likely continue as more renewables enter the supply stack. California provides an example of low market prices during hours with high solar generation, and relatively low load. A similar result is expected at the Mid-Columbia (Mid-C) hub due to the growth of solar generation. Price forecasts used in this study project a convergence of prices during heavy load and light load hours due to solar and storage growth (see Chapter 8).

The increase in weather-driven VER generation is also expected to contribute to increasing price volatility, which can produce extremes in both upward and downward directions. In times of low demand, such as during the shoulder seasons, there can be a surplus of power to the point of requiring curtailments of renewables, which can push prices to zero or even negative. At times of high demand, if there is limited wind or solar output, prices can spike up to reflect scarcity. These patterns are reflected in the price forecast NorthWestern uses in its simulation modeling.

While prices are expected to decline, flexible resources can provide value via the ability to quickly start up and adjust output. Batteries and fast ramping natural gas resources have the physical characteristics to react to market prices. In markets with high volatility, the ability to quickly react to price signals allows flexible resources to capture value that slow-moving, inflexible resources are not able to capture.

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[19] 2022 SRA Draft (nerc.com), pg. 5.

3.3. Organized Market Development

Market coordination among entities in the West is increasing. The W-EIM was created in 2014 and includes 19 members, with three more expected to join in 2023. This market, which focuses on intra-hour or real-time optimization, has proven to be beneficial from both resource management and financial perspectives. NorthWestern joined W-EIM in 2021 and is considering joining one of the two day-ahead markets being developed in the West. Well-designed day-ahead markets are expected to provide more value to customers than intra-hour markets such as W-EIM because the range of resources that can be optimized in the day-ahead timeframe is larger than the comparable set of resources that can be optimized in real-time. The ability to commit resources with longer start times in a coordinated, optimized manner is expected to lead to more efficient resource dispatch, with savings to customers.

The W-EIM is designed to discourage leaning on other participants for resources, and imposes several Resource Sufficiency (RS) tests on participants so that issues are addressed prior to the operating hour. Failure to pass W-EIM RS tests can lead to freezing transfers in the direction of failure as well as over- and under-scheduling charges for base scheduling error. The W-EIM RS requirements mean that NorthWestern needs to secure adequate capacity ahead of the operating hour to participate in the benefits of these markets and avoid penalties. Generally, a portfolio that is primarily sufficient and that has ramping capability makes it easier to pass W-EIM RS tests and maintain W-EIM participation.

The California Independent System Operator (CAISO) has been developing a day-ahead extension to W-EIM known as the Extended Day-Ahead Market (EDAM) since 2019. EDAM would be available to all W-EIM participants. CAISO has issued a series of issue papers and straw proposals, taken comments, and held technical workshops and discussions about the market design. The current timeline calls for a FERC filing and implementation activities in 2023 with go-live in 2024.

The Southwest Power Pool (SPP) is developing a competing day-ahead market proposal known as Markets+. This initiative began in late 2021. SPP plans to implement components of the governance structure of Markets+ in 2023 with a targeted go-live date in 2024.

NorthWestern has participated in both efforts from their beginnings and will continue to evaluate the pros and cons of each market. NorthWestern intends to delay a decision on joining until sufficient information on each market design and its governance model is fully developed, as well as an indication of which market our neighboring utilities intend to pursue.

3.4. Western Resource Adequacy Program (WRAP)

Resource Adequacy (RA) is the term used to describe an electric system's ability to meet demand under a broad range of conditions, subject to an acceptable standard of reliability. Currently, energy companies in the Northwest individually plan for resource adequacy, typically through their resource planning processes. In 2019, the Northwest Power Pool, now known as the Western Power Pool (WPP) began the effort now known as WRAP, an initiative to develop a resource adequacy program for the region. This initiative was driven by a recognition that the region could begin to experience power capacity shortages as soon as 2020, that by the mid-2020s the power capacity deficits could reach thousands of megawatts, and that regional cooperation could provide more efficiency than would be achieved by each energy company planning on its own. One of the program objectives is to leverage the geographic diversity benefits of the larger region to enhance planning and operations during times of peak energy demand. The ability of WRAP participants to pool and share resources during tight operating conditions is expected to lead to increased reliability and potential savings opportunities.

3.4.1. Program Status

NorthWestern has participated in WRAP as a founding member with representation on both the Participant Committee and the Operating Committee, as well as a number of ad-hoc committees and work groups. On August 31, 2022, WRAP made a filing with the Federal Energy Regulatory Commission (FERC) of the tariff that will implement the binding program.

Some of the key design elements are:

- WRAP includes a Forward Showing program and an Operations program.
- Each entity will be required to demonstrate in advance that it owns or has contracted for the physical capacity needed to meet its forecasted peak load plus a reserve margin.
- The program is technology neutral, meaning that any resource that can help meet the peak load requirement can participate in the program.
- Resources will be accredited based on their contribution to meeting peak load. An ELCC methodology is used for certain resource types.
- To qualify in the Forward Showing timeframe, resources must be accompanied by firm transmission.
- Contracts that are not linked to a specific resource or portfolio of resources will not qualify for resource adequacy.

Figure 3-6. WRAP Timeline

At the time of preparing this Plan, NorthWestern is committed to participating in the non-binding phase starting with the winter of 2022-2023 and summer 2023 (Figure 3-6). In late 2022, NorthWestern committed to the binding phase for potential implementation date in 2025 or 2026.

4. Energy and Environmental Policy

4.1. Introductory Statement

NorthWestern provides reliable and safe energy services at the most affordable rates possible while responsibly managing the natural resources under our stewardship. NorthWestern supports using renewable resources when consistent with the needs of the portfolio and our commitment to ensure our customers always get the energy they need in all weather conditions. Our commitment to environmental stewardship and compliance affects all facets of our business, including our resource procurement planning.

All forms of electric generation involve environmental impacts and mitigation requirements. NorthWestern employs a team of experts to ensure our projects are operated in compliance with environmental regulations and operating license requirements. Our December 2021 Edition of Bright Magazine highlights our environmental compliance and stewardship activities. This publication is available on our website.[20]

4.2. NorthWestern's Commitment to Net Zero Greenhouse Gas Emissions[21]

NorthWestern is committed to achieving carbon neutrality (i.e., Net Zero) for greenhouse gas emissions by 2050. Reaching Net Zero will require a series of incremental steps and investments in energy generation, infrastructure, technology, and sustainability practices, such as the electrification of our fleet. The technologies needed to reach this goal sooner are not currently available in a manner that is cost effective for our company or our customers. Our needs require technologies and resources that are proven to be successful and cost effective for both generation and capacity especially for critical long duration service. Additionally, regulatory and policy support will be critical in the speed of our transformation. For these reasons, NorthWestern believes the year 2050 is the appropriate realistic timeline for our commitment to reaching Net Zero carbon emissions.

NorthWestern is pledging to acquire only non-carbon emitting resources after 2035. As described in Chapter 8, the constraints for the PowerSIMM modeling runs included no carbon emitting resources allowed after 2035. State laws and regulations focusing on reliable and cost-effective electric service have been the primary drivers in developing portfolios for Montana. Our pledge to only acquire non-carbon emitting resources after 2035 must also comply with the applicable laws and regulations in place at the time of acquisition. As NorthWestern transitions its portfolio, new resources will be acquired using a competitive bidding process and with resource selections meeting Montana regulatory requirements. Additional resources needed to maintain resource adequacy will match the needs of customers with the most cost-effective resources available at that time.

NorthWestern is also progressing toward electrifying its fleet of vehicles and equipment and by 2030, intends to replace 30% of light-duty class vehicles, 20% of new medium and heavy-duty vehicles, and 30% of new bucket trucks with electric vehicles (EVs). In addition, by 2030, all new forklift replacements will be electric. NorthWestern's fleet drives 13 million miles each year to serve our customers, so the emission reductions of transitioning to EVs will be substantial.

In addition, in-depth analysis is being conducted to design programs for business customers to ensure our electric infrastructure is adequate and efficient for significant EV charging growth. Please see Chapter 9 for an overview of projected EV growth in our service territory and refer to Volume 2 Chapter 9 for additional detail on that study.

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[20] Bright Magazine: Environment 2021 by NorthWestern Energy - Issue.

[21] Net Zero by 2050 (northwesternenergy.com) see https://www.northwesternenergy.com/clean-energy/net-zero-by-2050.

4.3. River Management Partnerships

Partnering with agencies and private parties, NorthWestern employs an innovative approach to complying with our hydroelectric project FERC license requirements. Under a Memorandum of Understanding (MOU), NorthWestern, the US Fish & Wildlife Service, Montana Department of Fish, Wildlife and Parks, US Forest Service, US Bureau of Reclamation, and the US Bureau of Land Management work collaboratively to implement studies and projects to protect and enhance fish and wildlife habitat and water quality and support and enhance public recreation. Habitat improvement on rivers and tributaries is a high priority as is our program to protect endangered species and species of special concern and enhance their habitat. For the last 15 years, NorthWestern has partnered with agencies and two landowners to fund one such project at O'Dell Creek, which involved restoring over 16 miles of stream and 700 acres of wetlands. Montana artist Monte Dolack captured the restoration work in his painting "Restoring Our Waters" (Figure 4-1).

Figure 4-1. "Restoring Our Waters," an Original Painting by Montana Artist Monte Dolack, Captures the Transformation of O'Dell Creek.

Another example of NorthWestern's environmental stewardship is work the Company supports on Beaver Creek, a tributary to Holter Reservoir. The creek was identified 40 years ago as the most important, of the few, trout spawning tributaries to the reservoir, but in need of habitat improvement. In 2020, to increase trout spawning, NorthWestern provided funding to restore 0.6 mile of stream channel, 1 acre of wetland, and 6.4 acres of functional floodplain. Restoration of an additional 0.6 mile of stream channel, 0.75 acre of wetland, and 7.2 acres of functional floodplain was completed in 2022.

Figure 4-2. Beaver Creek Restoration 2022; Fish and Benthic Invertebrate Life Observed in Newly Constructed Pools and Riffles.

NorthWestern has provided funding each of the last 10 years to support the installation and operation of a system of 12 remote fish-tracking (RFID) stations located on a 225-mile stretch of the Missouri River from Great Falls to Fort Peck Reservoir. This network monitors a variety of native fish species to evaluate spawning movements and habitat requirements. Federally endangered pallid sturgeon stocked in the Missouri River 25 years ago are now old enough to spawn. New developments in RFID technology and equipment provided by NorthWestern allow biologists to track individual fish that move into tributaries for spawning, and satellite interfaces provide real-time access to fish movement data collected over such a large area. Tracking fish to spawning areas helps determine if these rare fish are naturally reproducing, and helps recover the species from endangered status.

4.4. Avian Protection Program

NorthWestern has a long standing commitment to deter birds from colliding with wind farm turbines and power lines, and from nesting on energized structures. To reduce the risk of power outages and osprey mortality, deterrents are installed on energized structures to prevent osprey from starting new nests. In addition, alternative nesting platforms are often installed nearby (Figure 4-3). Currently on our Montana electric system, there are more than 200 osprey platforms providing a safe home for these birds. This provides both a safe nesting location for osprey, which return to the same nest every year, and more reliable service for our customers. NorthWestern also communicates to the public about the threat baling twine presents to osprey when they use discarded twine in their nests because the birds and their offspring can become tangled in the twine, which often leads to bird fatalities.

Figure 4-3. **A NorthWestern Lineman Assists a University Biologist in Studying Active Osprey Nests.**

A NorthWestern engineer and a NorthWestern biologist recently collaborated to publish a paper in the scientific journal Human-Wildlife Interactions. Their paper examined and developed solutions to the unexplained power outages along the Company's largest transmission lines in central Montana. The 500 kV line runs from Colstrip, Montana to the state of Washington, and the mysterious outages that began in 2016-2017 had the potential to disrupt power supply across a large region. After several months of effort, the cause of outages was identified. At sunset one winter day, NorthWestern personnel saw common ravens arriving in large flocks to roost for the evening on the transmission towers. During counts on subsequent evenings the scale of the problem became evident - thousands of ravens roosted together on the 500 kV towers (Figure 4-4). Over time their droppings accumulated and encrusted insulators, which provided a path from conductors to the tower, thereby triggering faults. Analyses of data from a 15-year period demonstrated that the annual number of outages was closely related to raven abundance. The data also showed that raven populations in central Montana had increased exponentially. Fortunately, solutions developed by NorthWestern – excluding roosting ravens from portions of towers with perch deterrents, washing insulators with a helicopter-mounted sprayer, and installing silicon-coated insulators – have proven highly effective in reducing outages.

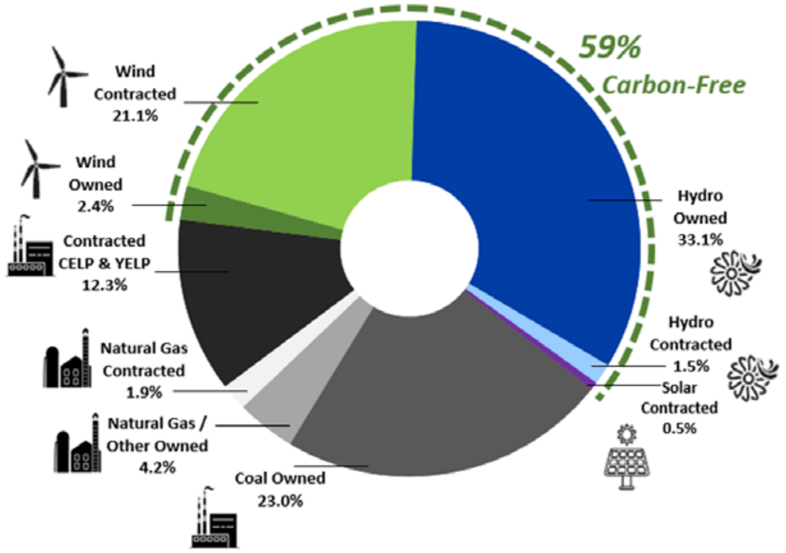
Figure 4-4. **Ravens Roosting on a 500 kV Tower**

4.5. Renewable Energy Resources

NorthWestern has made significant investments in renewable resources and cost-effective demand side management. This includes the 2014 acquisition of hydroelectric generation, which provides our customers long-term price stability for a significant portion of the portfolio that serves them, from a clean, renewable and carbon-free resource. Unlike other renewables, hydroelectric generation provides carbon-free energy and capacity as well as additional, or ancillary, services required for a reliable system (spinning and non-spinning reserves as well as on-demand generation increases or decreases). In addition to our carbon-free hydro resources, there is a large queue of solar, wind, and battery QF facilities in development (see Chapter 8 and Volume 2, Chapter 6).

NorthWestern's Montana portfolio includes resources that NorthWestern owns as well as contracts with QFs and other independent power producers. Energy sources include hydro, wind, solar, and thermal resources. As shown in Figure 4-5, 59 percent of the energy generated in 2021 came from carbon-free clean energy resources including hydro, wind, and solar.

Figure 4-5. **2021 Energy Generation from Owned and Contracted Resources - Montana**

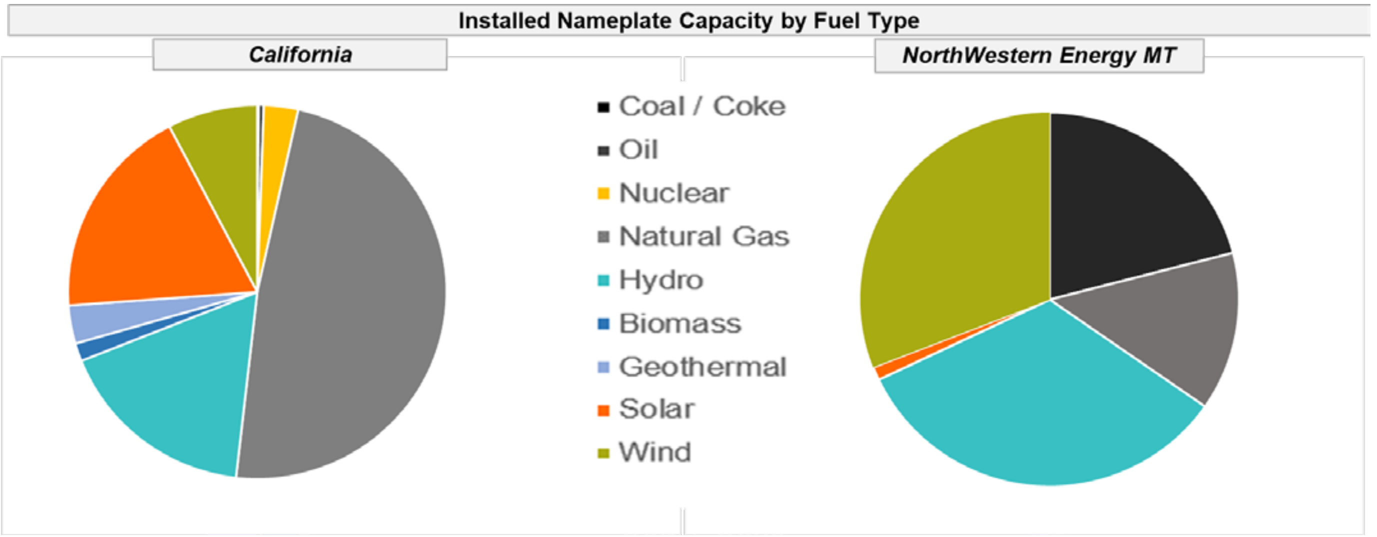


NorthWestern's portfolio of carbon-free generation compares favorably with California's generation mix. The following figures show a comparison of NorthWestern and California supply capacity by resource type using 2021 nameplate data. Overall, NorthWestern's portfolio contains a greater amount of installed carbon-free resources as a portion of total supply compared to the California supply (Table 4-1, Figure 4-6).

Table 4-1. Comparison of Resource Stacks, California and NorthWestern

	California[22]			NorthWestern Energy (MT)		
	MW	**Percent**		**MW**	**Percent**	
	2021	**of Total**	**Non-Carbon**	**2021**	**of Total**	**Non-Carbon**
Coal / Coke	99	0.1%		309	21.0%	
Oil	352	0.4%		0	0.0%	
Nuclear	2,393	2.9%	2.9%	0	0.0%	
Natural Gas	39,442	48.3%		202	13.7%	
Hydro	14,043	17.2%	17.2%	490	33.3%	33.3%
Biomass	1,266	1.6%		0	0.0%	
Geothermal	2,693	3.3%	3.3%	0	0.0%	
Solar	15,072	18.5%	18.5%	17	1.2%	1.2%
Wind	6,281	7.7%	7.7%	455	30.9%	30.9%
Total	**81,641**	**100.0%**	**49.6%**	**1,473**	**100.0%**	**65.3%**

Figure 4-6. Chart Comparison of California and NorthWestern, 2021



NorthWestern added the hydro resources to its portfolio in 2014 and more recently increased wind and solar installations from 2017 onwards. Figure 4-7 shows a historical timeline of when NorthWestern acquired its resource portfolio. Between 2011 and 2021, NorthWestern added approximately 800 MW of nameplate capacity from both owned and contracted resources to its generation portfolio, all of which is carbon free.

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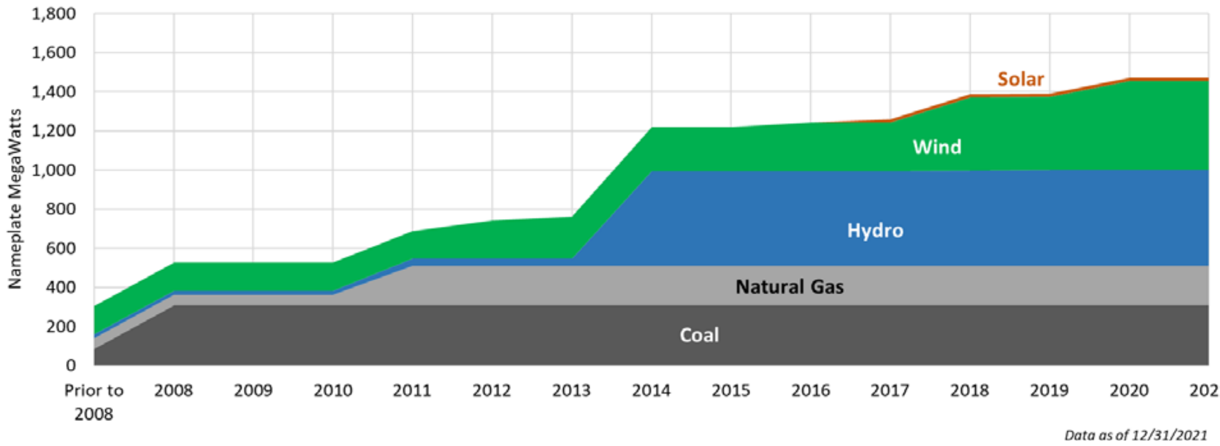
[22] CA capacity information from: https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/electric-generation-capacity-and-energy

Figure 4-7. Cumulative Timeline for Portfolio Additions of Owned and Long-Term Contracted Electric Resources



4.6. Key Environmental Risks

An environmental requirement that has changed since the last Plan is the regional haze rule (RHR).

4.6.1. Regional Haze Rule

The US Environmental Protection Agency (EPA) originally established the RHR in 1999. It required states to develop and implement plans to improve visibility in certain national park and wilderness areas. On June 15, 2005, the EPA issued final amendments to the rule. The goal of the rule is to reduce certain pollutants to improve visibility to natural conditions by 2064. These pollutants include fine particulate matter, nitrogen oxides, sulfur dioxide, certain volatile organic compounds, and ammonia. States were given until December 2007 to develop state implementation plans (SIPs) to comply with the rule. Montana did not develop a plan to comply, and EPA subsequently developed a Federal Implementation Plan (FIP) for Montana in September 2012 to cover the first planning period (2008 – 2018). The FIP did not include immediate requirements for Colstrip.

States were similarly expected to submit SIPs for the second planning period (2018-2028) by August 2022. Montana did submit a SIP to the EPA for this time period. The SIP did not call for additional controls at Colstrip during this second planning period. EPA's approval of Montana's SIP is still pending. For purposes of the Plan, it is assumed that Colstrip will not require additional material upgrades to comply with the RHR during the 20-year planning period of the Plan. Should a SIP or FIP require that Colstrip reduce emissions affecting visibility and those reductions require material upgrades, a detailed analysis would be required at that time.

5. LOAD SERVICE REQUIREMENT

5.1. Energy Forecast

5.1.1. Overview and Background

The COVID-19 pandemic and resulting lock-down in 2020 had a significant impact on retail loads. Total residential energy use was 2.3% higher in 2020 than 2019 on an actual basis, with unfavorable weather[23] contributing 3.3% negative growth and the pandemic contributing an estimated 5.6% positive growth. Total GS1-Secondary (small commercial) was 3.9% lower in 2020 than 2019 on an actual basis, with unfavorable weather contributing 1.2% negative growth and the pandemic contributing an estimated 2.7% negative growth. These are expected outcomes as people stayed home and many businesses closed or decreased operations. NorthWestern's load-serving obligation was 1.7% lower in 2020 than in 2019. However, GS1-Secondary energy rebounded in 2021 to near pre-COVID-19 levels and residential use continued its strong growth, resulting in NorthWestern's load serving obligation increasing 3.4% over 2020 and surpassing pre-COVID-19 levels. NorthWestern will continue to monitor customer electricity use trends in order to make appropriate adjustments to annual long-term forecasts.

NorthWestern has developed customer, energy, and peak demand forecasts in a consistent manner for several planning cycles. The basis for the customer forecast is population within NorthWestern's service territory, and the primary basis for the energy and peak demand forecasts are the customer forecast and normal weather forecast. Other than a few variations that have been added into the process from time to time, these components have and continue to serve as the explanatory variables in the linear regression models that produce the forecasts.

NorthWestern's DSM programs have been and continue to be incorporated into the energy and peak demand forecasts as well. Prior year DSM acquisition is inherent in the energy and peak demand regression results, while future DSM acquisition is forecasted and applied to the regression results to reflect both a "gross" and "net" of DSM value for the energy and peak demand forecasts. NorthWestern plans to acquire an average of 4 MW per year or 78 average megawatts (aMW) in DSM energy savings between 2022 and 2042, excluding losses, with contributions to 2036 summer and winter peaks projected at 114 MW and 123 MW, respectively.

The impact of NEM is a variable introduced into the 2018 forecast. A NEM penetration study conducted by NREL on behalf of the MPSC and subsequently refined by Navigant to tailor to NorthWestern's distribution and transmission system, concluded that, barring any changes to existing tariffs in which NEM customers receive the full retail value for energy generated, installed capacity of NEM solar PV systems will grow from about 25 MW in 2021 to 202 MW in 2040. The result of this growth is over 31 aMW in energy and a contribution to the summer peak of 105 MW in 2040, excluding losses. The Navigant study can be found in the electronic files supporting this Plan.

5.1.2. Methodology and Energy Forecast

The methods of estimating future annual energy usage are rate class specific and have been unchanged in the last several planning cycles. Residential and GS-1 Secondary usage combined represents approximately 88% of the total energy load-serving obligation. These forecasts are based on more detailed regression models using the specific customer-class forecast and normal weather, defined as the 10-year average historical total degree days (heating plus cooling), as the explanatory variables that produce the annual load forecasts. Usage for all other customer classes is based on historical actual annual usage coupled with adjustments for known changes to future usage. In addition, transmission line losses are included in all customer classes' forecasts. Note, the total annual energy and peak forecasts are allocated into monthly values that are input into PowerSIMM using weather-normalized monthly energy and peak data.

Expected DSM and NEM are also projected throughout the 20-year forecast period and subtracted from Residential and GS-1 Secondary energy forecasts as well as the winter and summer peak forecasts. The projected DSM and NEM have a substantial impact on projected annual load; the forecasted average annual growth rate for the retail load-serving obligation excluding future DSM and NEM is 0.9%, while the average annual growth rate when including future DSM and NEM is 0.3%. Figure 5-1 illustrates the impact of DSM and NEM on future energy usage. Historical DSM and NEM energy and peak impacts are inherent in the regression results in that they are included in historical load figures, the basis for forecasting future loads. Table 5-1 shows the actual and forecasted retail supply loads broken into commercial, residential, and "other"[24] categories.

Figure 5-1. Impact of DSM and NEM on Load Forecast, Including Transmission Losses (Annual MWh)

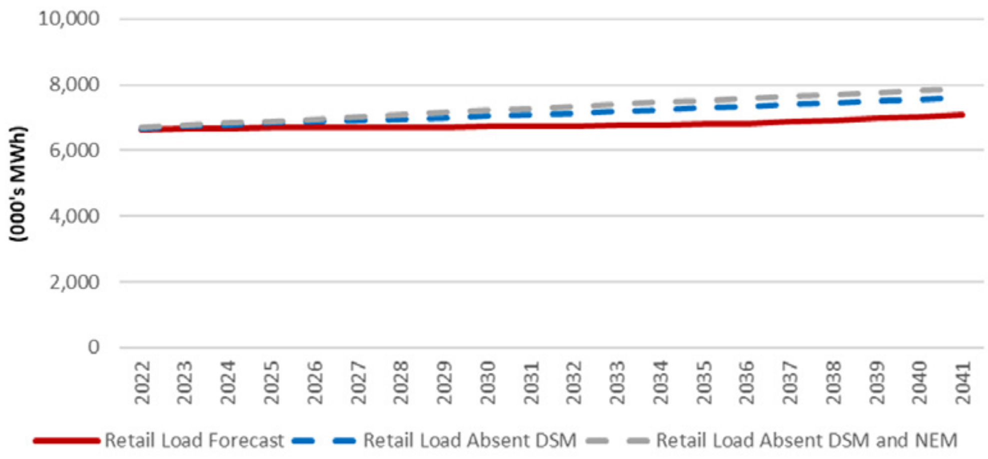


Table 5-1. Actual and Forecasted Retail Loads

Year	Retail Load (MWh)	Annual Growth Rate	Commercial (MWh)	Annual Growth Rate	Residential (MWh)	Annual Growth Rate	Other (MWh)	Annual Growth Rate
2005	5,917,037		3,071,706		2,220,022		625,309	
2010	6,152,195	*0.8%*	3,191,964	*0.8%*	2,490,486	*2.3%*	469,745	*-5.6%*
2015	6,366,384	*0.7%*	3,274,285	*0.5%*	2,527,102	*0.3%*	564,998	*3.8%*
2020	6,397,983	*0.1%*	3,103,918	*-1.1%*	2,821,959	*2.2%*	472,106	*-3.5%*
2025	6,688,836	*0.9%*	3,239,012	*0.9%*	2,986,171	*1.1%*	463,653	*-0.4%*
2030	6,724,600	*0.1%*	3,180,518	*-0.4%*	3,080,429	*0.6%*	463,653	*0.0%*
2035	6,793,391	*0.2%*	3,154,658	*-0.2%*	3,175,080	*0.6%*	463,653	*0.0%*
2040	7,029,871	*0.7%*	3,242,911	*0.6%*	3,323,306	*0.9%*	463,653	*0.0%*
20-YR CAGR		*0.3%*		*0.0%*		*0.7%*		*-0.1%*

Notes: Includes losses, DSM, and Solar PV-NEM. The "other" category includes substation, transmission, lighting, irrigation and Yellowstone National Park loads.

5.1.3. Customer Forecast

Again, residential and GS-1 Secondary customers make up 88% of NorthWestern's load-serving obligation but they make up 98% of the Company's electric customers. The primary driver of the customer forecast is the projected population in NorthWestern's service territory, which is comprised of 37 of Montana's 56 counties. As shown in Table 5-2, actual and expected population growth for the state of Montana and NorthWestern's service territory is about the same; approximately 0.8%. Total accounts are projected to grow at about a 1.2% annual rate, higher than the population growth rate because of total new connects in residential single and multi-family housing units and commercial buildings. Residential and GS1-Secondary accounts are projected to grow at annual rates of 1.1% and 1.4%, respectively.

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[23] Unfavorable weather is a warmer winter and/or a cooler summer

[24] The "other" category includes substation, transmission, lighting, irrigation and Yellowstone National Park loads

Table 5-2. Actual and Forecasted Population and Customers

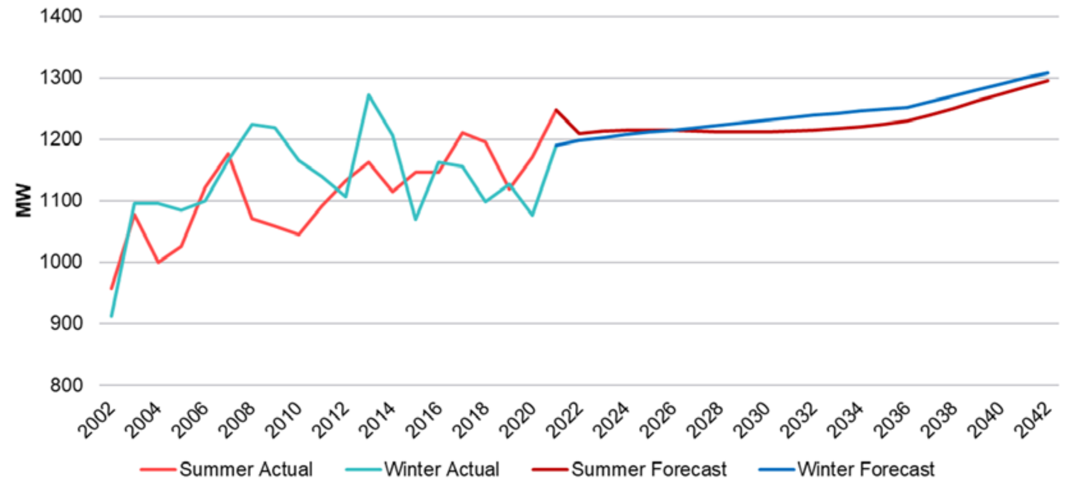
Year	Montana Population	*Annual Growth Rate*	NWE Srvc Territory Population	*Annual Growth Rate*	NWE Total Accounts	*Annual Growth Rate*	NWE Residential Accounts	*Annual Growth Rate*	NWE GS1-Secondary Accounts	*Annual Growth Rate*
2005	940,102		734,415		315,755		253,124		55,491	
2010	990,643	*1.1%*	774,995	*1.1%*	338,804	*1.4%*	270,571	*1.3%*	60,872	*1.9%*
2015	1,030,475	*0.8%*	805,038	*0.8%*	359,565	*1.2%*	287,387	*1.2%*	64,554	*1.2%*
2020	1,080,577	*1.0%*	847,005	*1.0%*	385,230	*1.4%*	307,390	*1.4%*	70,014	*1.6%*
2025	1,132,055	*0.9%*	887,393	*0.9%*	412,033	*1.4%*	327,825	*1.3%*	76,343	*1.7%*
2030	1,184,310	*0.9%*	928,328	*0.9%*	438,581	*1.3%*	348,481	*1.2%*	82,235	*1.5%*
2035	1,234,745	*0.8%*	967,748	*0.8%*	464,144	*1.1%*	368,373	*1.1%*	87,906	*1.3%*
2040	1,282,411	*0.8%*	1,004,907	*0.8%*	488,329	*1.0%*	387,124	*1.0%*	93,340	*1.2%*
20-YR CAGR		*0.8%*		*0.8%*		*1.2%*		*1.1%*		*1.4%*

5.2. Peak Demand Forecast

5.2.1. Summer and Winter Peaks

NorthWestern's retail load peak forecast was developed using a linear regression model with weather (cooling degree day (CDD) and heating degree day (HDD)), temperature, monthly energy, and total customers serving as the explanatory variables. Projected DSM and NEM values were then subtracted from the regression results to calculate the peak demand forecasts. NEM is not a factor on the winter peak but it does have a strong impact on the summer peak. The summer peak growth rate is projected to be 0.3% when factoring in DSM and NEM while the winter peak growth rate is projected to be 0.4% when factoring in DSM. Figure 5-2 shows historical observed loads from 2002 to 2021, and then the demand forecasts from 2022 to 2042. Winter is defined as December through February and Summer is defined as July and August.

Figure 5-2. Observed and Forecast Peak Load by Summer and Winter Months



5.3. Demand Side Management Acquisition and Programs

NorthWestern uses the Total Resource Cost (TRC) test to evaluate Demand Side Management opportunities for cost effectiveness. The TRC test is a ratio of benefits (the net present energy savings value based on the lifetime avoided energy and capacity costs) to total DSM program costs (utility program implementation costs and incremental customer costs). Typically, a TRC benefit-to-cost ratio of 1.0 or greater indicates that a DSM measure or program is cost effective.

NorthWestern updated the avoided cost calculations for commercial and residential DSM in 2022 using the hourly DSM energy profiles provided by Nexant in 2020.[25] For avoided costs of capacity, Ascend calculated ELCC values for DSM capacity contribution using PowerSimm. These calculations, described in Chapter 8, resulted in capacity contribution percentages for commercial and residential DSM measures of approximately 61% and 95%, respectively. The cost of capacity was based on the least cost capacity resource from the 2019 Plan, a 50 MW aeroderivative combustion turbine ("Aero CT"). Aero CT capital costs and fixed O&M were escalated to 2023 dollars to calculate a revenue requirement value of $139.43/kW-yr, which represents the cost of procuring capacity in 2023. The corresponding levelized around-the-clock avoided cost of capacity values, considering the capacity contribution of DSM and NorthWestern's capacity need through time, are approximately $18/MWh and $31/MWh.

The avoided cost of energy was calculated using PowerSimm. Commercial and residential DSM were modeled separately as generating resources with hourly forecasts matching the Nexant 8760 profiles, extended through a 30 year period, and included in the portfolio. The resulting avoided costs of energy were approximately $22/MWh and $23/MWh respectively.

Currently, NorthWestern invests in DSM pursuant to its 20-year 2017 DSM Acquisition Plan, 2019 Electricity Supply Resource Procurement Plan, and 2020 Supplement to the Plan. As part of NorthWestern's 2017 DSM Acquisition Plan, an annual DSM acquisition goal of 3.90 aMW each year for the first 5 years (2016-2017 through 2020-2021) and 3.35 aMW each year for the remaining 15 years (2021-2022 through 2035-2036) was established. Values for 2036-2037 through 2041-2042 assume the same level of increase as was included in the original forecast. The annual aMW targets include estimates of annual energy savings capability contributed from measures and actions implemented under both electric supply DSM programs (including Northwest Energy Efficiency Alliance (NEEA) energy savings), and Universal System Benefits (USB) programs. The annualized energy savings represent the capability of installed conservation and efficiency measures to produce energy savings for a full year. While estimated savings from USB-funded programs are included, the expenses are not included as they are covered with USB revenues.

The corresponding forecast costs are based on NorthWestern's 2017 DSM Acquisition Plan and recent DSM programs' operation results, where values for 2036-2037 through 2041-2042 assume the same level of increase as was included in the original forecast. Forecasted increases occur due to NorthWestern's expectation that remaining cost-effective DSM will become more expensive to acquire. Actual acquisition and costs will vary from the forecast.

Table 5-3. DSM, NEEA, USB Acquisitions

DSM/NEEA/USB Acquisition Target, DSM/NEEA/USB Acquisition Reported, DSM/NEEA Expense (no USB Expenses included*)								
Tracker Year	DSM NEEA USB Acquisition Target (aMW)	DSM Acquisition Reported (aMW)	NEEA Acquisition Reported (aMW)	USB Acquisition Reported (aMW)	Total DSM NEEA USB Acquisition Reported (aMW)	DSM Program Expense $	NEEA Program Expense $	Total DSM NEEA Expense
2013-2014	6.00	4.90	1.14	0.59	6.62	7,526,764	1,812,813	9,339,577
2014-2015	6.00	3.99	1.32	0.38	5.69	4,399,366	1,015,012	5,414,378
2015-2016	6.00	3.41	1.14	0.58	5.13	4,831,958	1,219,625	6,051,582
2016-2017	4.35	4.25	1.23	0.35	5.82	5,303,406	1,221,149	6,524,555
2017-2018	4.35	5.26	1.54	0.27	7.07	6,283,806	1,523,720	7,807,527
2018-2019	4.35	7.35	1.98	0.24	9.58	7,744,933	916,514	8,661,446
2019-2020	4.35	7.10	1.72	0.27	9.09	7,195,779	1,262,384	8,458,163
2020-2021	3.77	5.92	1.01	0.17	7.10	7,097,383	1,272,568	8,369,952
2021-2022	3.77	7.41	1.07	0.15	8.63	9,067,559	1,282,896	10,350,455
Cumulative	**42.93**	**49.59**	**12.16**	**2.99**	**64.74**	**59,450,954**	**11,526,680**	**70,977,634**
*Although energy savings produced by USB programs are counted toward the overall annual aMW target, USB programs are funded through a separate charge, and USB spending is not reported or included.								

Table 5-3 above shows acquisition target, acquisition reported for DSM, NEEA, and USB, as well as expenses for DSM and NEEA over years 2013-present.

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[25] In January 2020, Nexant, Inc. completed the Updated Electric Energy Efficiency Market Potential Study for NorthWestern (Updated Electric Potential Study). This study built upon the previous assessment completed in 2017 by incorporating updated calculations of the costs of energy and capacity that DSM measures can allow NorthWestern to avoid, as well as updated end-use load shapes and lighting end-use measure assumptions, which helped to characterize the value of annual energy and peak demand savings.

5.3.1. DSM Acquisition and Expense Forecasts

Tables 5-4 and 5-5 show the Electric DSM Acquisition Goals that include energy savings estimates from DSM, NEEA, and USB for each year and Forecast Program Expenses for DSM and NEEA over the 20-year period. The DSM savings component is developed from the Electric Potential Study; the NEEA component represents NorthWestern's expectation of the electric savings produced through NEEA activities for NorthWestern's Montana service territory; and the USB component represents NorthWestern's current expectations of the electric savings that will be generated by USB programs.

Table 5-4. **DSM Forecast Acquisition**

Actual or Forecast Electric DSM Acquisition				
Tracker Year	DSM Actual or Forecast Acquisition (aMW)*	NEEA Actual or Forecast Acquisition (aMW)*	USB Actual or Forecast Acquisition (aMW)*	Total DSM + NEEA + USB Actual or Forecast Acquisition (aMW)*
2018-2019	7.35	1.98	0.24	9.58
2019-2020	7.10	1.72	0.27	9.09
2020-2021	5.92	1.01	0.17	7.10
2021-2022	7.41	1.07	0.15	8.63
2022-2023	2.95	0.40	0.42	3.77
2023-2024	2.95	0.40	0.42	3.77
2024-2025	2.95	0.40	0.42	3.77
2025-2026	2.95	0.40	0.42	3.77
2026-2027	2.95	0.40	0.42	3.77
2027-2028	2.95	0.40	0.42	3.77
2028-2029	2.95	0.40	0.42	3.77
2029-2030	2.95	0.40	0.42	3.77
2030-2031	2.95	0.40	0.42	3.77
2031-2032	2.95	0.40	0.42	3.77
2032-2033	2.95	0.40	0.42	3.77
2033-2034	2.95	0.40	0.42	3.77
2034-2035	2.95	0.40	0.42	3.77
2035-2036	2.95	0.40	0.42	3.77
2036-2037	2.95	0.40	0.42	3.77
2037-2038	2.95	0.40	0.42	3.77
2038-2039	2.95	0.40	0.42	3.77
2039-2040	2.95	0.40	0.42	3.77
2040-2041	2.95	0.40	0.42	3.77
2041-2042	2.95	0.40	0.42	3.77
Cumulative	**86.78**	**13.79**	**9.23**	**109.80**

*2018-2019, 2019-2020 , 2020-2021, and 2021-2022 are actual DSM + NEEA + USB acquisition (aMW); 2022-2023 through 2035-2036 are forecast DSM + NEEA + USB acquisition (aMW) which comes from the 2017 DSM Acquisition Plan; Values for 2036-2037 through 2041-2042 assume the same level of increase as was included in the original forecast. Total DSM Acquisition (aMW) includes DSM program potential savings calculated from the Nexant Electric Energy Efficiency Potential Study and savings estimates from the Northwest Energy Efficiency Alliance (NEEA) initiatives. NEEA is a DSM-funded program held to the same cost-effectiveness tests as other DSM funded programs.

Table 5-5. **DSM Forecast Acquisition Expense**

Actual or Forecast Electric DSM Expense			
Tracker Year	DSM Actual or Forecast Incremental Program Expense*	NEEA Actual or Forecast Program Expense*	Total DSM + NEEA Actual or Forecast Incremental Program Expense*
2018-2019	$ 7,744,933	$ 916,514	$ 8,661,446
2019-2020	$ 7,195,779	$ 1,262,384	$ 8,458,163
2020-2021	$ 7,097,383	$ 1,272,568	$ 8,369,952
2021-2022	$ 9,067,559	$ 1,282,896	$ 10,350,455
2022-2023	$ 9,697,911	$ 1,282,896	$ 10,980,807
2023-2024	$ 5,558,059	$ 1,500,000	$ 7,058,059
2024-2025	$ 5,835,962	$ 1,500,000	$ 7,335,962
2025-2026	$ 6,127,760	$ 1,500,000	$ 7,627,760
2026-2027	$ 6,434,148	$ 1,500,000	$ 7,934,148
2027-2028	$ 6,755,856	$ 1,500,000	$ 8,255,856
2028-2029	$ 7,093,649	$ 1,500,000	$ 8,593,649
2029-2030	$ 7,448,331	$ 1,500,000	$ 8,948,331
2030-2031	$ 7,820,748	$ 1,500,000	$ 9,320,748
2031-2032	$ 8,211,785	$ 1,500,000	$ 9,711,785
2032-2033	$ 8,622,374	$ 1,500,000	$ 10,122,374
2033-2034	$ 9,053,493	$ 1,500,000	$ 10,553,493
2034-2035	$ 9,506,168	$ 1,500,000	$ 11,006,168
2035-2036	$ 9,981,476	$ 1,500,000	$ 11,481,476
2036-2037	$ 10,480,550	$ 1,500,000	$ 11,980,550
2037-2038	$ 11,004,577	$ 1,500,000	$ 12,504,577
2038-2039	$ 11,554,806	$ 1,500,000	$ 13,054,806
2039-2040	$ 12,132,547	$ 1,500,000	$ 13,632,547
2040-2041	$ 12,739,174	$ 1,500,000	$ 14,239,174
2041-2042	$ 13,376,133	$ 1,500,000	$ 14,876,133
Cumulative	**$ 210,541,163**	**$ 34,517,257**	**$ 245,058,420**

*2018-2019, 2019-2020 , 2020-2021, and 2021-2022 are actual spend; 2022-2023 forecast comes from Electric DSM Forecast Costs in Exhibit DLW-1 in Dkt. 2022.09.083 PCCAM; Values for 2036-2037 through 2041-2042 assume the same level of increase as was included in the original forecast.

NorthWestern notes that a future DSM budget is a long-term estimate that may be used for long-range resource planning. Each one-year budget forecast is based on current year results and knowledge gained from past program operation and is likely to deviate from the values established in the long-range budget forecast presented above, as evidenced by the five years of data in the DSM and NEEA Spend columns presented in table 5-5.

5.3.2. DSM, NEEA, and USB Programs

NorthWestern continues to offer a variety of programs, services and resources to help our Montana customers to better manage energy costs. The following are current electric DSM Programs funded through energy supply rates:

- **E+ Residential Electric Programs for Existing Homes and New Construction** – Cost effective electric energy savings measures are included in these programs. NorthWestern's programs implementation contractor, DNV, provides implementation services for these programs.
- **E+ Lighting Programs** – Cost effective light-emitting diode (LED) offerings are included in NorthWestern's E+ Residential and E+ Commercial Lighting Programs, where DNV provides implementation services for these lighting programs. The following mechanisms to distribute and encourage purchase and use of ENERGY STAR® LEDs and fixtures, and other energy-efficient lighting measures, are offered to commercial and residential customers:
    - ↳ Rebates to commercial customers for energy-efficient lighting equipment and controls, including rebates for prescriptive LED measures;
    - ↳ Rebates to residential customers for prescriptive LED measures; and
    - ↳ LED Manufacturer Buy-down Program – buy-down of LED prices for residential customers at various retailers throughout NorthWestern's Montana service territory.

Federal regulations are being implemented through two new final rules related to general service lamps (GSL). One expands the definition of GSL and general service incandescent lamp (GSIL) ("the definitions rule").

Another imposes a sales prohibition of less than 45 lumens per watt on all GSLs ("the backstop rule"). These rules will apply to manufacturers, distributors, and retailers and are expected to be progressively enforced with enforcement of the rules beginning Jan. 1, 2023 for manufacturers and expected to begin Aug. 1, 2023 for distributors and retailers. NorthWestern will continue working to understand the implications of these rules on its programs and measure offerings.

- **E+ Commercial Electric Rebate Program for New or Existing Facilities** – Rebates are available to electric customers for qualifying electric measures. The E+ Commercial Electric Rebate Program for Existing Facilities includes incentives for motor rewinding. Currently, four electric motor service centers in NorthWestern's electric service area perform efficient motor rewinding service.
- **E+ Business Partners Program** – Provides customized incentives to commercial and industrial customers for electric conservation, based on the metrics of the customer's specific project(s). Examples of projects include measures to improve lighting; heating, ventilating and cooling (HVAC) systems; refrigeration; air handling; and pumping systems. New and existing facilities are eligible.
- **E+ Commercial Programs' Contractors** – NorthWestern continues contracting with firms to provide services in support of acquiring energy efficiency in the commercial sector. NorthWestern compensates these contractors on a performance basis, with payment based on a percentage of the energy conservation resource value of each individual project that is completed with the contractor's involvement.

These contractors are supported by DNV employees who have responsibility for communication of E+ programs to commercial/small industrial customers in an effort to identify, qualify, and cultivate energy saving projects for follow-up by the contractors, along with implementation services for the prescriptive rebate programs. Services provided by these contractors include marketing to architect/engineering firms and trade/industry associations in Montana, direct contact with candidate businesses with energy savings potential, surveys and assessments of buildings and facilities, technical assistance for building owners, assistance with required engineering analysis and modeling, and assistance to customers with forms, contracts, and other paperwork used in and necessary for participation in these programs.

- **Northwest Energy Efficiency Alliance (NEEA)** – NEEA is a regional non-profit organization supported by utilities, public benefits administrators, state governments, public interest groups, and energy efficiency industry representatives. Through regional leveraging, NEEA encourages "market transformation" or the development and adoption of energy efficient products and services in Montana, Washington, Idaho, and Oregon. NEEA's regional market transformation activities target the residential, commercial, industrial and agricultural sectors. NEEA also funds some of the infrastructure development of ENERGY STAR Northwest and other above-code new home activities.

Additional electric energy savings are produced from Universal System Benefits (USB) funded programs that will continue into the foreseeable future. The electric energy savings produced from these USB programs are counted toward annual DSM goals. The costs to operate these programs are not included in the energy supply resource planning process. The following energy saving programs are supported through USB funds:

- **E+ Free Weatherization Program** – Provides insulation and other efficiency improvements at no cost to Low Income Home Energy Assistance Program (LIHEAP) qualified space-heating customers of NorthWestern.
- **E+ Energy Audit for the Home** – Free virtual energy assessment and mail-in survey audit.
- **E+ Irrigator Program** – Provides financial incentives for the installation of energy efficient electric conservation in irrigation systems.
- **Building Operator Certification** – Building Operator Certification is an international professional development program for managers and operating engineers of commercial and public facilities and is available to commercial customers in partnership with the Northwest Energy Efficiency Council.
- **E+ Renewable Energy Program** – Provides financial incentives to non-profit and government/public electric customers for qualifying small-scale solar photovoltaic, wind, and hydroelectric systems in Montana.

5.3.3. DSM Updates

NorthWestern recently completed an RFP[26] process to provide evaluation services for an end use and load profile study, an electric energy efficiency assessment study, and a demand response potential assessment study.

There are three major focus areas for these Montana-based studies:

1. Detail the energy end-use characteristics of customers in the NorthWestern electric and natural gas supply territories;
2. Identify and characterize the remaining, achievable, cost-effective electric energy efficiency using costs and savings of energy-efficient measures compared to standard practices to determine what electric energy efficiency is technically feasible, economically feasible, and achievable, including efficiency supply curves for a range of avoided costs.
3. Identify and characterize the electric demand response potential costs and savings of demand response measures compared to standard practices to determine what demand response is technically feasible, economically feasible, and achievable in NorthWestern's market for a range of avoided costs.

Additionally, comparison will be made to NWPCC's 2021 Power Plan as well as to the 2016 NorthWestern Energy Assessment of Energy Efficiency Potentials with 2020 Updates.

NorthWestern has executed a contract with Applied Energy Group (AEG) to complete this work and project kickoff was held in late February 2023.

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[26] See Volume 2 Chapter 5 for the DSM RFP issued in September 2022 related to a new End Use Study, an Electric Potential Assessment Study, and a Demand Response Potential Assessment Study.

6. Existing Resource Portfolio

6.1. NorthWestern's Generation Portfolio

NorthWestern serves its retail customers with a diverse mix of hydro, wind, solar, and thermal generation resources. Resources in NorthWestern's portfolio are a combination of owned and contracted resources. The map in Figure 6-1 shows the location of most NorthWestern resources for the Montana territory.

Hydro

NorthWestern has 497 MW of hydro capacity on its system with individual generation units ranging in size from 94 MW to 0.2 MW. This critically important carbon-free generation resource provides the largest portion of energy on the system, followed by wind.

Capacity and Thermal Contracts

NorthWestern has 387 MW (winter) of capacity and thermal contracts on its system in 2023 that help ensure energy is available when called upon. These contracts provide a critical element in achieving a reliable system.

Wind

NorthWestern owns or contracts for 455 MW of carbon-free wind capacity. Most of the wind is located in central Montana.

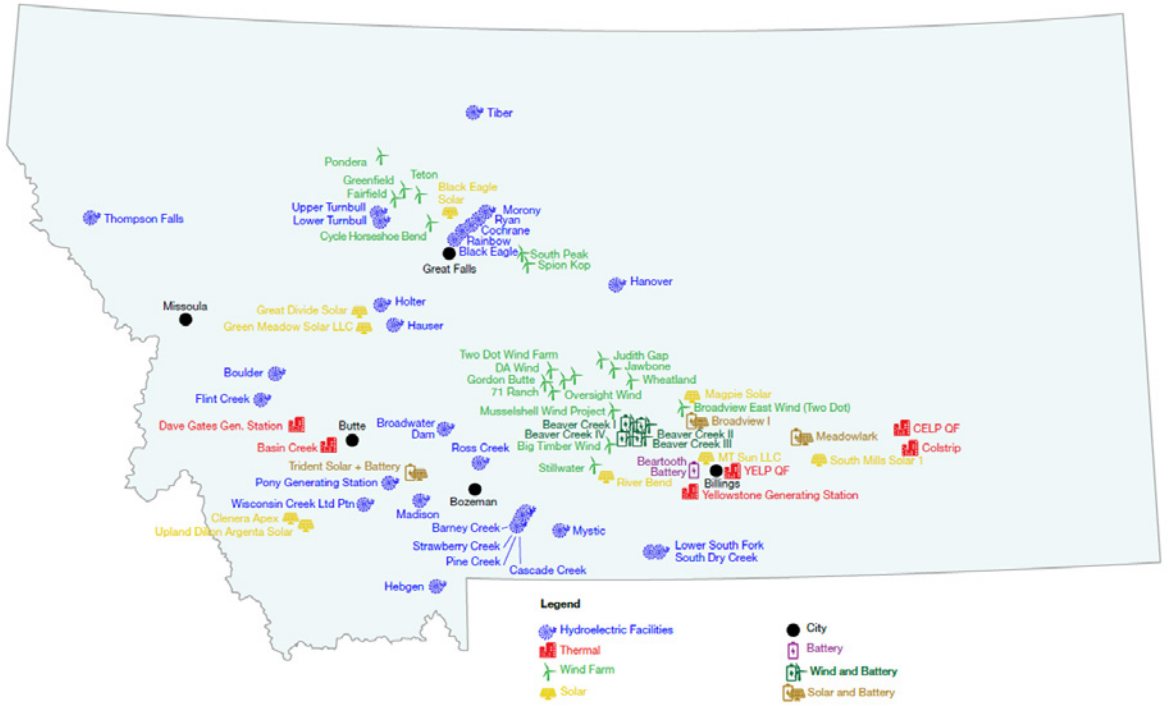
Colstrip

Colstrip is the largest single resource in NorthWestern's portfolio. NorthWestern currently owns 30% of Unit 4 for a total of 222 MW. NorthWestern has a reciprocal sharing agreement for 15% of Unit 3. NorthWestern has recently acquired Avista's ownership share of 111 MW on Units 3 and 4, for a total of an additional 222 MW, effective 2026. In recent years, Colstrip's future has become increasingly uncertain due to environmental policies in Washington and Oregon. A significant amount of capacity contribution towards NorthWestern's load obligation will be lost if Colstrip retires early. For this reason, modeling in this plan focused heavily on the uncertainty in the future of Colstrip.

Natural Gas

NorthWestern has a number of natural gas generation resources on its system. These units provide important flexible energy, contingency reserves, frequency regulation, and ramping capability that help ensure reliable operation of NorthWestern's system. Natural gas units play a key role in responding to changing production from weather dependent resources.

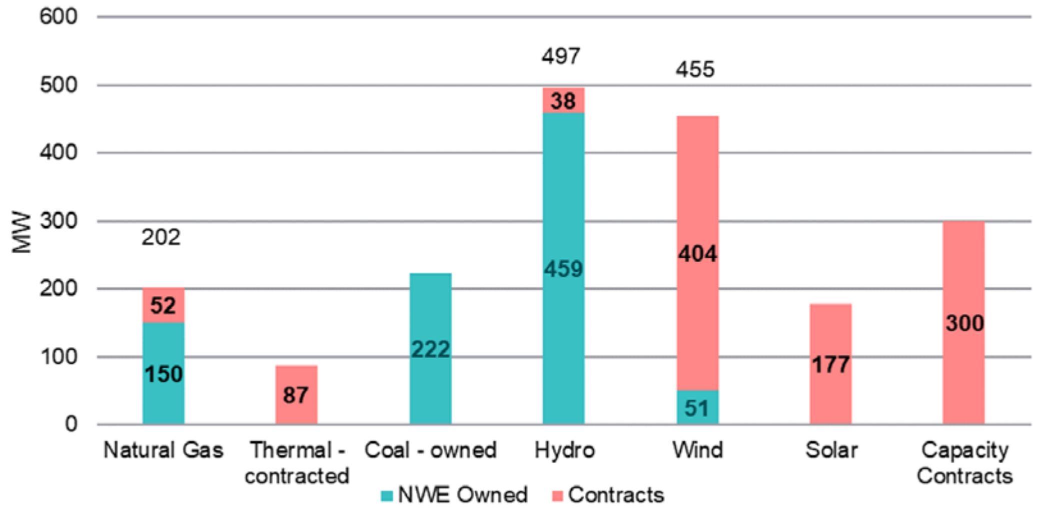
Figure 6-1. Generating Resources in Montana



A complete listing of all NorthWestern's supply resources and characteristics may be found in Volume 2 Chapter 6.

The amount of installed nameplate capacity by resource type in NorthWestern's current portfolio is shown in Figure 6-2. Hydro and wind make up the two largest resource types by category with most of the hydro owned by NorthWestern and most of the wind procured under contracts. Capacity contracts shown in the figure represent energy capacity deals NorthWestern has procured with other marketing entities. The capacity contracts category is not tied to a specific generation type.

Figure 6-2. Nameplate Capacity of Owned and Contracted Resources (2023)



From a resource adequacy perspective, the nameplate capacity of resources does not convey the ability of a resource to serve load. Variable resources are accredited a capacity value based on an ELCC analysis which is described in more detail in Chapter 8. The accredited capacity indicates the fraction of a resource's nameplate capacity that can reliably serve load. For wind and solar, the accredited capacity is generally much lower than the nameplate capacity, which is based upon the energy source's contribution to peak load hours.

Figure 6-3 shows a comparion of nameplate capacity with seasonal accredited capacity based on the WRAP as well as peak load and market-acquired capacity contracts for 2023. ELCC values are shown separately for winter and summer seasons. Seasonal values for solar and hydro show the variable ability of hydro and solar to serve load changes throughout the year. NorthWestern tracks seasonal ELCC values to understand how resources can help with the summer and winter load peaks.

Figure 6-3. **Capacity Comparison by Season (2023), WRAP**

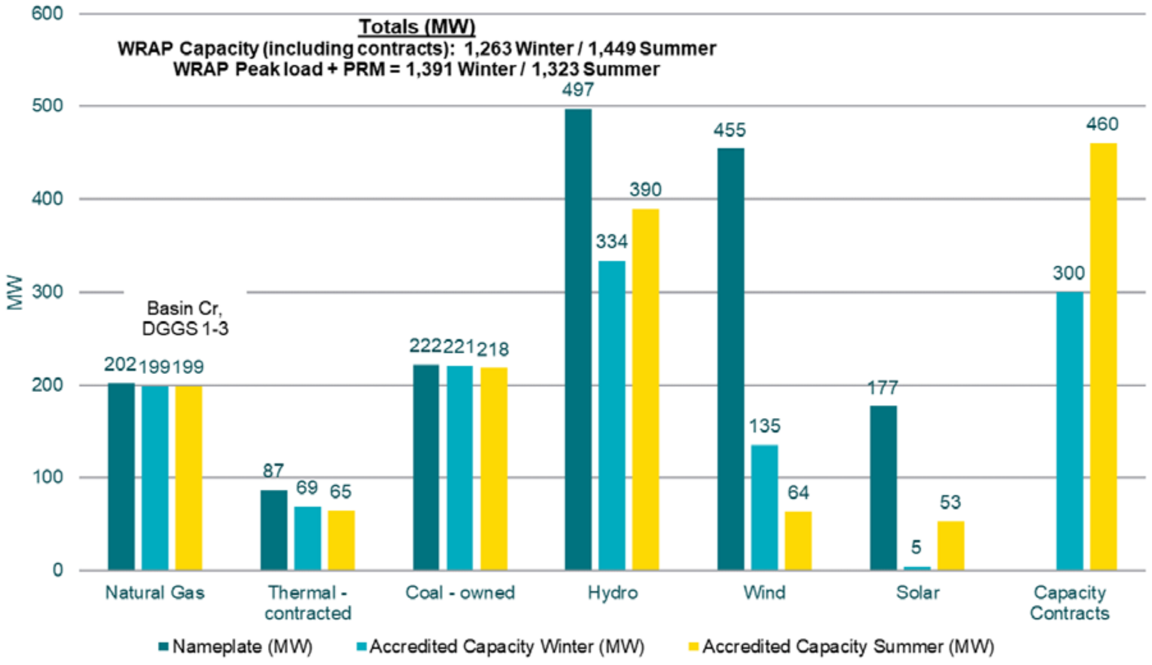


Table 6-1 evaluates correlation between VER resource (wind and solar) generation and NorthWestern's actual load as well as the average settled Mid-C prices from Powerdex, from 2017 through 2021. It can help explain the relatively low ELCC values that they are assigned. A correlation coefficient close to 1 indicates a positive or negative correlation between data. Small values close to zero indicate low or no correlation. As shown here, wind exhibits little to no correlation with load or prices. Solar has some correlation to summer loads but no correlation in the winter and no correlation to prices. This means that generation direct from these resources (without storage) is often poorly fit to NorthWestern's load peaks and also is not economically timed.

Table 6-1. **Correlation of Wind and Solar Generation with Loads and Prices**

VER Correlation with Load			
	Annual	**Winter**	**Summer**
Wind	0.01	-0.21	0.04
Solar	0.33	0.19	0.58
VER Correlation with Mid-C Price			
	Annual	**Winter**	**Summer**
Wind	-0.03	-0.16	-0.02
Solar	0.03	-0.07	0.11

More information on ELCCs is presented in Chapter 8 and additional details on ELCC values can be found in Volume 2. NorthWestern uses unit ELCC values provided through WRAP to determine its capacity position by season.

6.2. Planning for the Future

NorthWestern aims to achieve and maintain resource adequacy in the near future to reduce the risk of blackouts due to insufficient generation or transmission capacity to meet load. NorthWestern must continue to focus on an adequate capacity position to meet its PRM and consider multiple approaches to attain it.

Section 3.1 of this Plan highlights an "elevated risk" of insufficient capacity reserves in our region. The proposals submitted in response to NorthWestern's June 2020 Short Term Capacity RFP reflected the insufficient capacity in the region. The total amount offered by all bidders to the RFP was 398 MW, of which only 350 MW were likely to meet future resource adequacy program requirements. In the past NorthWestern has seen responses that are many times larger than the request amount. The result of this RFP was much lower, which suggests that the depth of available resources for purchase is shrinking. The RFP was flexible and solicited bids from existing resources for terms between one and three years and allowed for variation in the products solicited. In the RFP, NorthWestern stated an intent to purchase 25 to 300 MW in varying forms, regardless of the type of generating resource or fuel type. The RFP also stated NorthWestern's flexibility in contract forms. Thus, the design of the RFP itself was not likely to limit responses; rather it appears to be a result of scarcer regional resources.

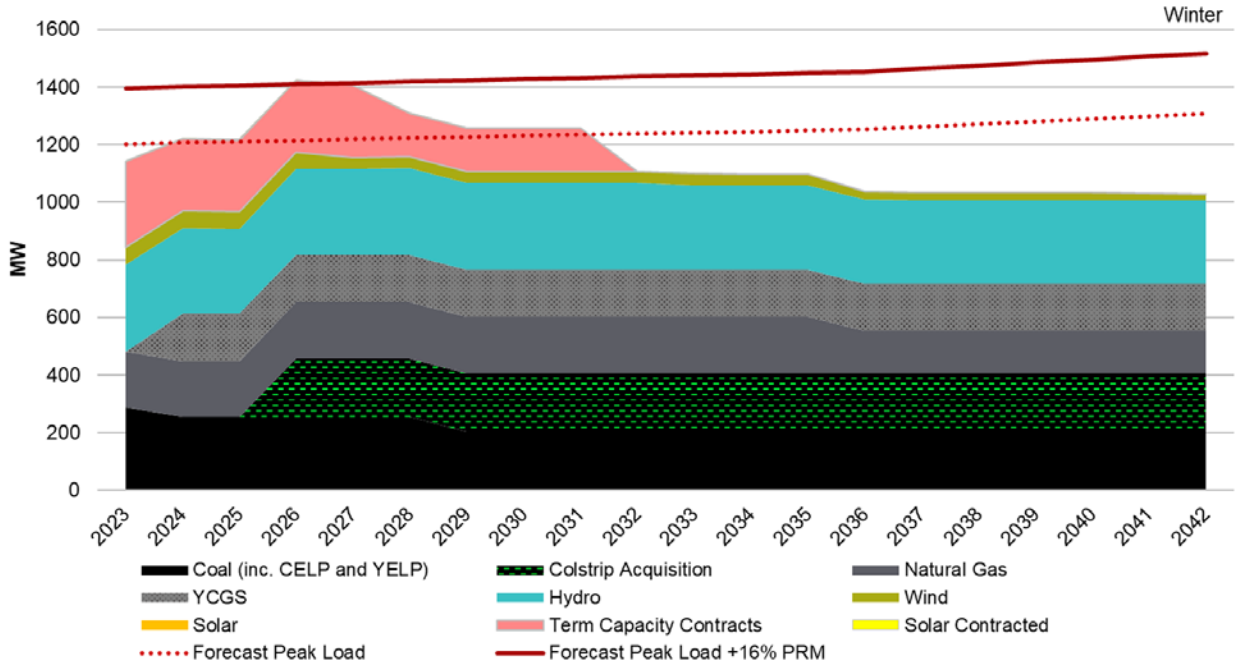
A number of factors complicate the capacity outlook of NorthWestern. These include the potential early closure of Colstrip, the current construction of YCGS, the large number of potential QF projects in NorthWestern's queue (see Chapter 2.6.3), and NorthWestern's position in the WRAP.

In the below figures, each resource type and its associated capacity contribution is shown for NorthWestern's portfolio. Figure 6-4 shows NorthWestern's winter capacity position using the historical view of ELCC by resource type, rather than individual resource ELCCs prescribed by the WRAP. For clarity, ELCC values based on historical data calculated relative to NorthWestern's load and portfolio will be referred to as "NorthWestern Historical ELCC".

Next, Figure 6-5 shows NorthWestern's winter capacity associated with the WRAP. The WRAP ELCC values express how resources contribute to resource adequacy over the broader region and are referred to as "WRAP ELCC". The WRAP assigns ELCC values to each resource individually, rather than by resource type. Figure 6-5 can be compared to 6-4 to see how the WRAP affects NorthWestern's position. Specific ELCC values can be found in Volume 2. As expected, NorthWestern's resources receive higher ELCC values when evaluated as part of a wider region, and that equates to an improved capacity positon for NorthWestern.

Common also to the graphs is displaying the forecast load for each season and the forecast plus a PRM to facilitate evaluation of resource adequacy over time. Taking NorthWestern's existing portfolio and projecting out 20 years shows a continued need to focus on acquiring capacity resources. As the figures show, NorthWestern has less of a capacity need early in the planning period, while the need increases in the future with the reduction of thermal generation capacity. This is true in both the historical and WRAP ELCCs views.

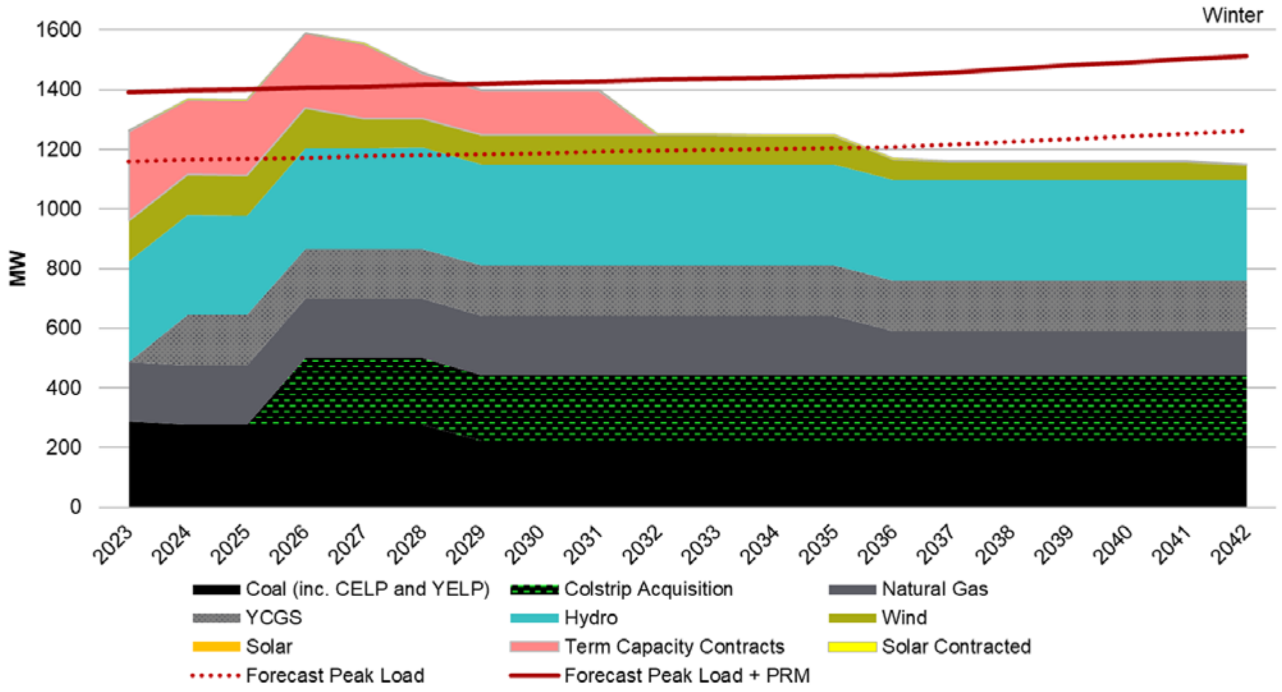
Figure 6-4. NorthWestern's Winter Capacity with Existing Resources Based on NorthWestern Historical ELCCs



Using the WRAP capacity values shows the benefits of regional resource coordination (Figure 6-5). Both hydro and wind resources are assigned more winter capacity under WRAP, which results in improvements in NorthWestern's capacity position.

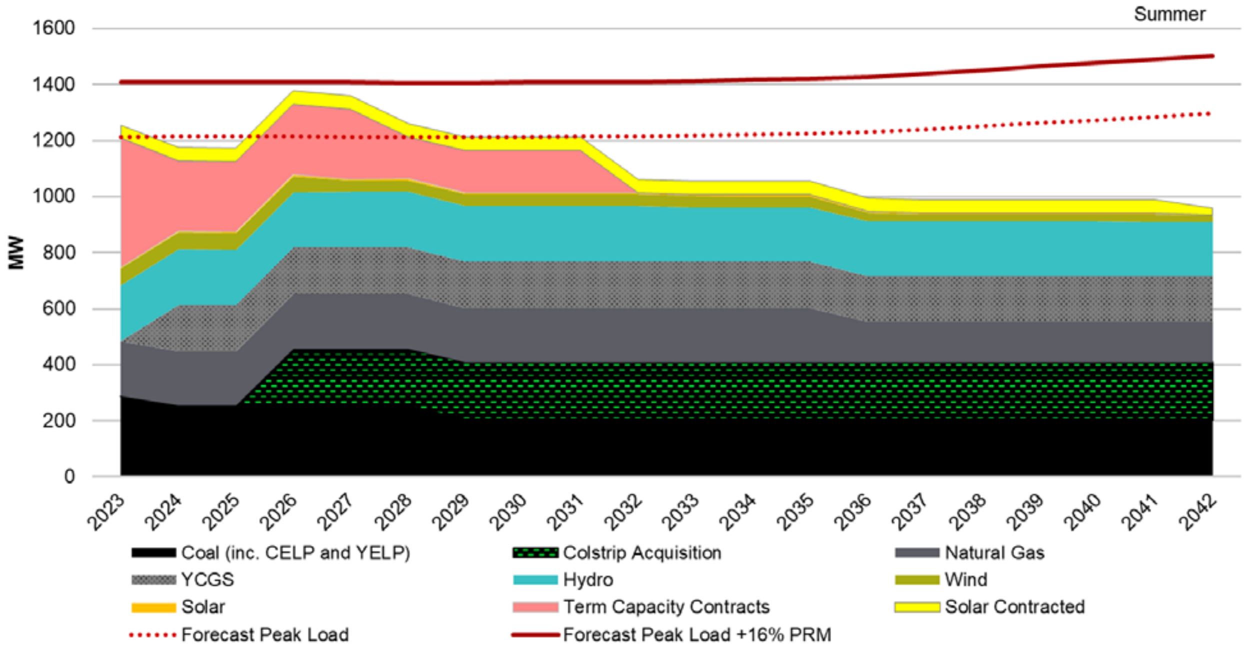
The small winter deficits that remain under WRAP in years 2023-2025 may be covered by market purchases or QF completions (see Volume 2, Chapter 2).

Figure 6-5. NorthWestern's Winter Capacity with Existing Resources Based on WRAP ELCCs



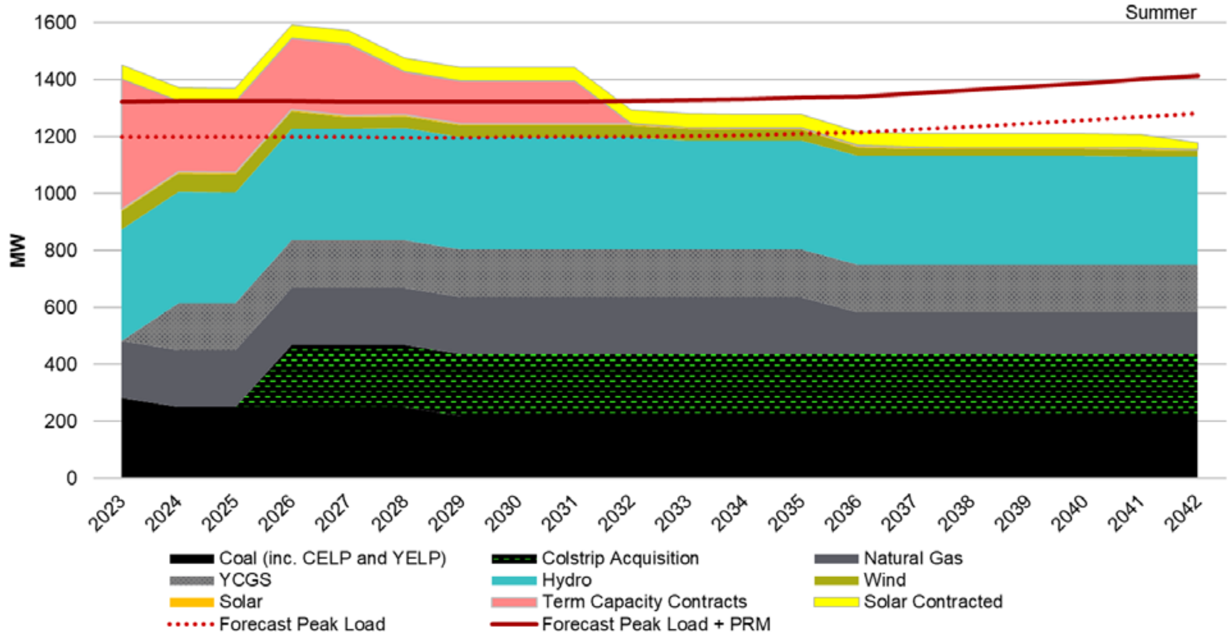
Figures 6-6 and 6-7 repeat this comparison of historical ELCC values to the WRAP values for the summer season.

Figure 6-6. NorthWestern's Summer Capacity with Existing Resources Based on NorthWestern Historical ELCCs



Consistent with previous findings, the hydro accreditation increases significantly under WRAP. In this summer comparison, NorthWestern becomes resource adequate for several years under WRAP with existing and contracted resources.

Figure 6-7. NorthWestern's Summer Capacity with Existing Resources Based on WRAP ELCCs

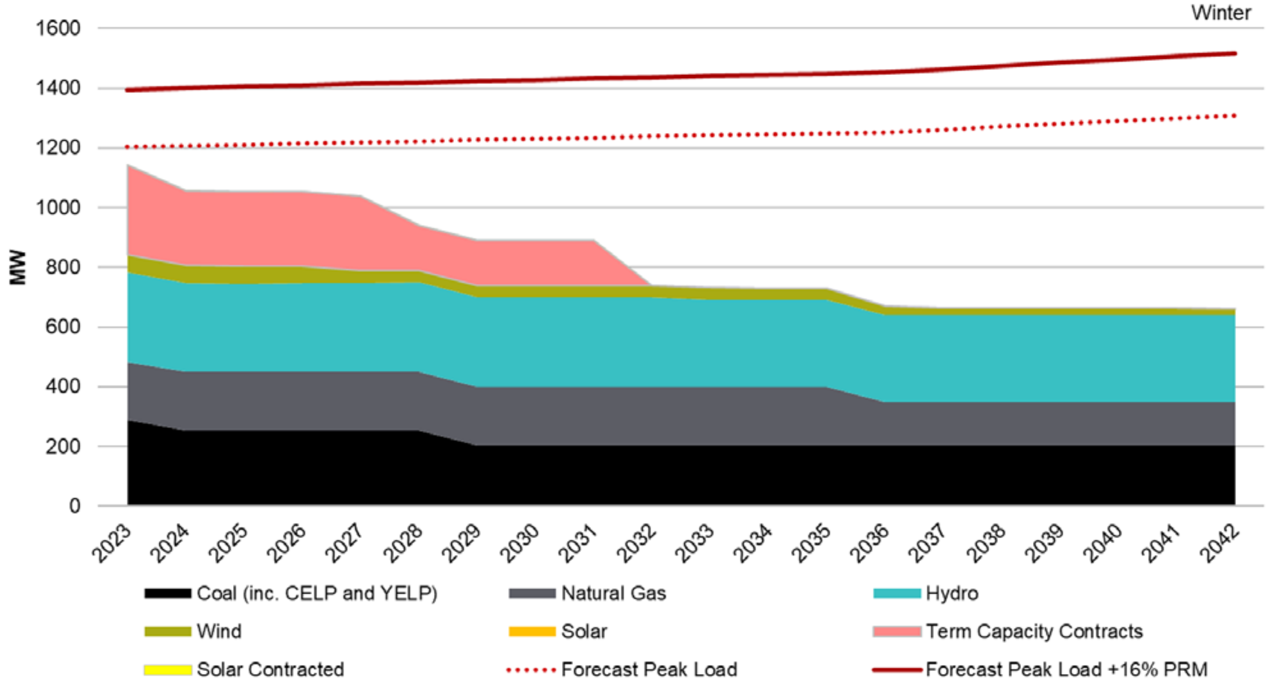


Figures 6-4 through 6-7 assume YCGS comes online in 2024. Without added resources, NorthWestern will continue to rely on market imports to satisfy load requirements. NorthWestern entered into capacity contracts in the 2020-2021 timeframe, which has helped the capacity position significantly, but the contracts will not be enough to provide resource adequacy and ensure reliability over the planning period. Without YCGS and other additional resources, the capacity position of NorthWestern falls further below the PRM.

6.3. The Benefits of Adding Long-term Resources

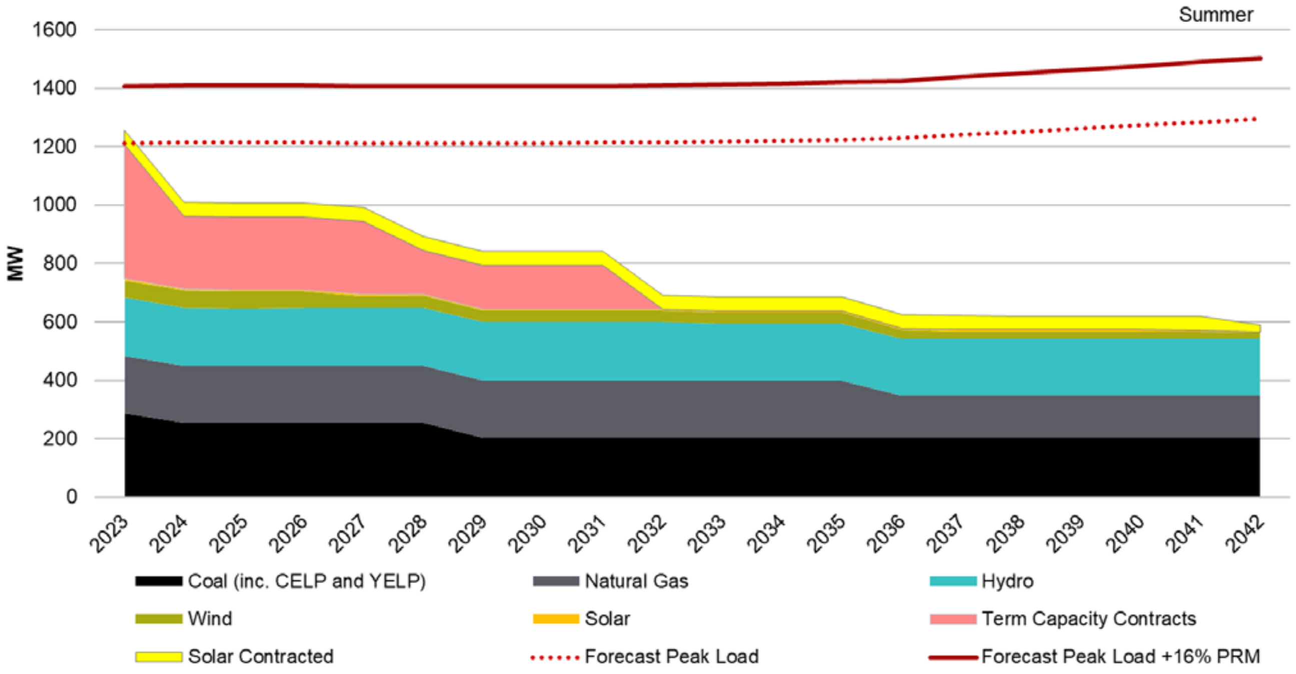
Both YCGS and the Colstrip acquisition are key components of the plan to achieve resource adequacy. YCGS is a fast-ramping reciprocal internal combustion engine (RICE) plant with a nameplate capacity of 175 MW. Its accredited capacity and altitude adjustment translates to 168 MW of fast ramping, firm generation that will provide NorthWestern more ability to balance large swings in variable generation, such as wind and solar. YCGS will also be able to provide value to NorthWestern customers through the W-EIM due to its ability to quickly ramp its generation up or down depending on the real-time prices in the W-EIM. Generally, a portfolio that is sufficient and that has ramping capability makes it easier to pass W-EIM RS tests and maintain W-EIM participation. The Colstrip acquisition is also important as it adds reliable, long-duration and cost-effective capacity that covers large deficits in the NorthWestern's portfolio. Figures 6-8 and 6-9 now show NorthWestern's portfolio without YCGS and the Colstrip acquisition and the resultant worsening of capacity deficits. Even under the WRAP with both resources online (as shown in Figures 6-5 and 6-7) NorthWestern falls below the PRM in later years.

Figure 6-8. NorthWestern's Winter Capacity without YCGS and Colstrip Acquisition, Historical ELCCs



Without YCGS and the Colstrip acquisition, NorthWestern's capacity falls well below the PRM target of 16% in both winter and summer seasons.

Figure 6-9. NorthWestern's Summer Capacity without YCGS and Colstrip Acquisition, Historical ELCCs



As shown, the capacity from YCGS and the Colstrip acquisition both are critical to achieve resource adequacy in the near term. While both are helpful separately, the depth of the projected deficits and resultant market exposure and reliability risk justify securing both resources.

A recent cold weather period in December 2022 (12/20 to 12/23) underscores the importance of NorthWestern's existing reliable generation, and the need for additional firm generation. During the highest load days of the event, NorthWestern relied on its hydro and thermal (gas and coal) assets while still experiencing significant energy shortfalls that required market purchases – see Figure 6-10. Solar and wind contributed very little, as expected, due to the short winter days and atmospheric conditions associated with the arctic air mass. The average contribution of solar resources during those four days was 4 MW; for wind resources it was 50 MW. In contrast, the hydro and thermal assets averaged 212 and 461 MW, respectively. NorthWestern imported significant amounts of energy to get through this event, peaking at 536 MW or ~45% of the total load obligation for Hour Ending (HE) 19 on 12/22 (see Chapter 7 and Table 7-1 for more details). Since this was a regional event, energy prices were elevated and NorthWestern paid high prevailing prices to make up for the shortfall. As shown in Figure 6-10, Mid-C hourly prices from Powerdex ranged from ~$600 to $1,800/MWh. To guard against future price exposure and reliability concerns, NorthWestern is committed to the Colstrip acquisition and to completing YCGS. Both of those energy sources are proven to perform in extreme weather events and can be dispatched according to load and price signals.

Figure 6-10. December 2022 Cold Weather Event – Load and Prices

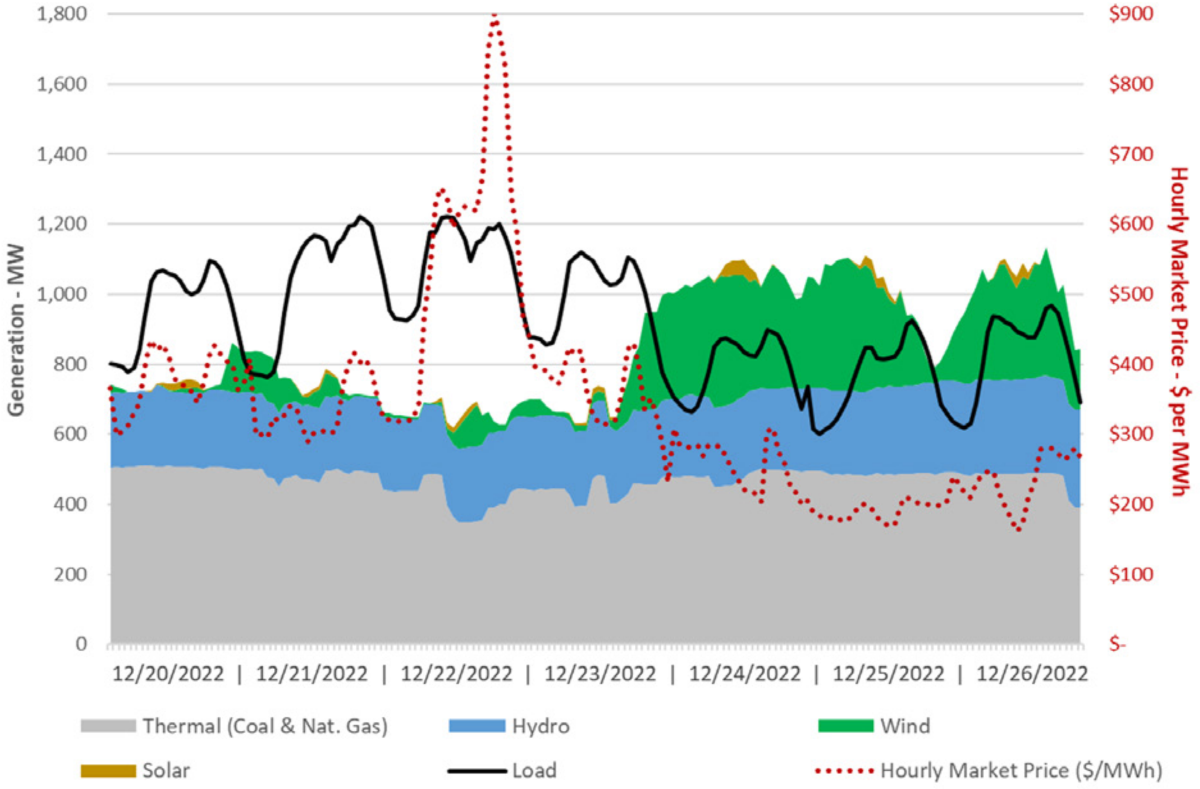
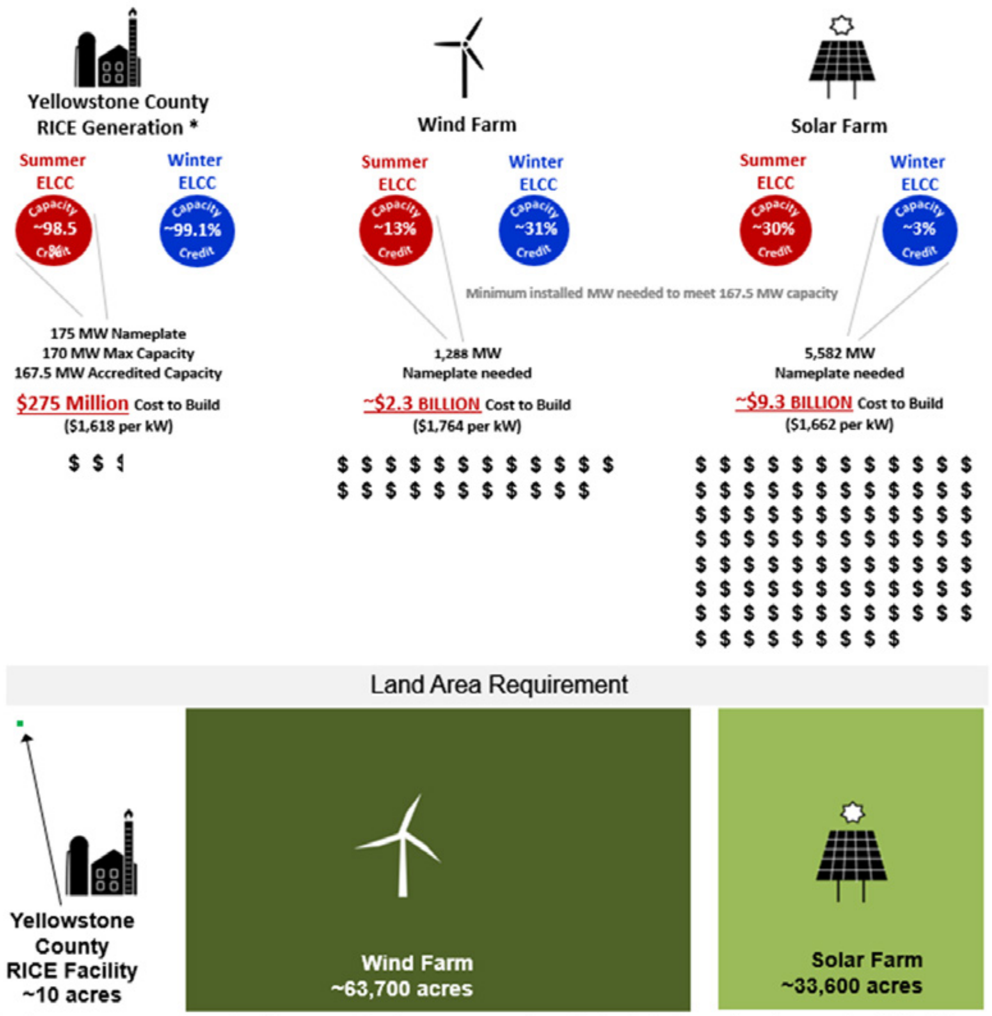


Figure 6-11 compares the cost and land use for wind and solar options that are scaled to match YCGS's 167.5 MW of firm summer capacity. This comparison is only for YCGS as it is a new build, whereas the Colstrip acquisition is a reallocation of an existing resource. Seasonal WRAP ELCC values are displayed for each resource type. Then, cost and land area calculations were produced using the minimum seasonal WRAP values, as indicated, to equate back to YCGS's reliable summer capacity level of 167.5 MW. With current resource cost and land use assumptions, wind would be ~8X more expensive and solar ~34X. The land use difference is orders of magnitude different when compared to the ~10 acre footprint of YCGS. Equivalent wind and solar installations would cover ~100 and 52 square miles, respectively. Figure 6-11 uses the resource cost values from Aion Energy LLC (contained in Vol. 2, Appendix F); however, under the IRA, certain build-specific factors may result in investment tax credits of 6 to 30%. While these tax credits would reduce overall wind and solar costs, the YCGS plant remains the most economical option.

Figure 6-11. Cost and Land Area of 167.5 MW of Capacity[27] [28]



** Yellowstone County Generating Station will have a nameplate of 175MW. However, due to altitude and other factors, the maximum capacity of this facility is expected to be 170MW. YCGS carries a summer capacity credit of 98.5% (167.5 MW capacity contribution versus 175 MW nameplate).*

Note: Capacity Credit factors for all generation listed are based on Effective Load Carrying Capability (ELCC) values from the Western Resource Adequacy Program (WRAP) as of January 2023.

The cost per kW per fuel type via Aion Energy LLC.

Cost Calculation: 167.5 MW of capacity from Yellowstone County RICE Facility. 167.5 MW divided by Capacity Credit then times the cost per fuel type equals total capex investment. Each dollar sign below each generation type represents $100 million of capital investment.

Capacity is a key driver of energy supply planning because a utility must plan to have sufficient capacity to meet the highest momentary energy demand over the course of the year. It must also have adequate energy to meet customers' needs over a prolonged period.

As noted above, NorthWestern continues to evaluate its capacity position under a variety of scenarios. The previous graphs in this chapter assumed Colstrip operates through 2042 and some assume a 2024 commercial operation date for YCGS. Table 6-2 shows NorthWestern's seasonal peak load and resource position as a snapshot view for 2023 and 2026 under both historical ELCCs and WRAP accreditations. The 2026 snapshot was chosen to reflect NorthWestern's position with both YCGS and the Colstrip acquisition in effect. The WRAP resource values and lower load obligations lead to higher total portfolio capacity. Both factors result in surpluses for both winter and summer seasons under WRAP.

The bottom portion of table 6-2 looks at long-term capacity impacts that could significantly impact NorthWestern's capacity position, namely the early closure of Colstrip as well as a non-complete outcome for YCGS. The two "If Colstrip Closes" scenarios show losses of 255 MW and 220 MW, respectively, representing NorthWestern's existing share and the additional acquisition capacity. Included in the 255 MW figure is the Rosebud Power Plant

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[27] Wind land usage based on information from: Harrison-Atlas, D; Maclaurin, G.; Lantz, E. Spatially-Explicit Prediction of Capacity Density Advances Geographic Characterization of Wind Power Technical Potential. Energies 2021, 14, 3609.

[28] Solar land usage based on internal review of solar installations in the Western U.S.

operated by CELP, which is assumed to be dependent on the waste coal stream tied to the mining efforts that supply the Colstrip plant power. These scenarios are presented to underscore the importance of both YCGS and the Colstrip acquisition to building an adequate portfolio and to demonstrate the depth of the capacity reduction in their absence.

Table 6-2. **2023 Seasonal Resource Adequacy Position and Capacity Scenarios**

Seasonal Resource Position - Historical ELCC Values			
	Summer/Winter		**Notes**
2023 Peak Load	1,213 / 1,203	MW	Increases to 1,308 in 2042
Planning Reserve	16	%	Approximate
Total Peak Need	1,407 / 1,395	MW	
Existing Capacity	1,256 / 1,144	MW	Seasonal ELCC values
2023 Position	-151 / -251	MW	
2026 Position	-32 / 14	MW	
Seasonal Resource Position - WRAP			
	Summer/Winter		**Notes**
2023 Peak Load	1,199 / 1,160	MW	Increases to 1,281 in 2042
Planning Reserve Margin	10.4 / 19.9	%	
Total Peak Need	1,323 / 1,391	MW	
Existing Capacity	1,452 / 1,265	MW	
2023 Position	129 / -126	MW	
2026 Position	269 / 186	MW	
Long-Term Capacity Scenarios			
If Colstrip closes (existing share)	-255	MW	Effective cap of Colstrip: ~220MW (WRAP); CELP: ~35MW
If Colstrip closes (acquisition)	-220	MW	
If Yellowstone Generating Station not completed	-168	MW	Currently under construction
Combined potential capacity reduction	-643	MW	

The views in this section exclude QFs that do not have a signed agreement with NorthWestern. This approach captures the fact that there is significant uncertainty associated with QF schedules and also that some do not advance to completion. Chapter 8 and Volume 2, in contrast, explore NorthWestern's capacity positions with proposed QFs included.

In summary, NorthWestern shows a need for capacity over the entire 20-year planning period assuming its current portfolio and no QF additions. The portfolio is more adequate under WRAP, with both the Colstrip acquisition and YCGS completion being important contributors to achieve adequacy. However, deficits appear later in the planning period even with both of these resources. Given the uncertainty of the future and considering the critical need for a reliable system, NorthWestern remains open to acquiring additional capacity to achieve the least-cost, reliable portfolio.

6.4. Duration Analysis

Duration in power planning refers to the elapsed time that generation resources are needed and available to serve load. An important distinction can be made between long duration resources versus resources that have a shorter reliable duration, due to generator type, design, or fuel limitations. Long-duration resources are indispensable during extended peak load events such as cold snaps or heatwaves. Therefore, duration is an important factor in supply planning and influences the selection of supply resources.

Duration was analyzed using NorthWestern's observed load for a 5-year period from 2017 to 2021. Five load levels were analyzed, beginning at the 800 MW level, which corresponds to the current sum of NorthWestern's long duration hydro and thermal resources[29]. The number of elapsed load events that exceeded each level was quantified, in addition to the longest duration exceedance, and percent of total load hours. This same analysis was performed with observed retail load as well as retail load adjusted by subtracting observed wind and solar generation, termed "net load". The net load more accurately captures the load the NorthWestern had to serve from its long duration resources.

Table 6-3 shows the results associated with the full retail load. Notable is that retail load reached or exceeded 800 MW 1,568 separate times, amounting to roughly 37% of the five-year interval. The longest continuous duration event was 164 hours, which translates to approximately a week that load did not drop below 800 MW. The higher load tiers of 900 and 1,000 MW also show frequent exceedances with 1,130 events (~17% of interval) and 425 events (~5% of interval), respectively. Finally, the top two tiers show fewer events and shorter event durations; however, these peak load times are the most critical times. These top tiers coincide with more extreme weather conditions that pose higher risks to life and property should the energy system not have the capacity and duration characteristics to reliably serve load. Although the number of events is lower in these top two load tiers, they are still observed many times each year. Note that the longest duration event at 1,150 MW would still require at least 8 hours of reliable capacity.

Table 6-3. **Duration Analysis of Full Retail Load**

Retail Load					
	Load Level (MW)				
	800	**900**	**1,000**	**1,100**	**1,150**
Number of events exceeding load level	1568	1130	425	138	51
Longest event (hours)	164	45	17	11	8
Total hours at or above	16,428	7,288	2,316	513	151
% of 5 year interval	37.49%	16.63%	5.28%	1.17%	0.34%

Table 6-4 shows the duration results associated with net load (retail load - renewables). This view is presented to show the load obligation that had to be served from NorthWestern's long duration resources. The net load level of 800 MW was associated with 899 events (~16% of five-year study interval), with the longest continuous event lasting 91 hours. As shown, it is common to have long duration peak load events that reach or exceed 1,000 MW, many times a year. The top two load tiers are less common, but combined, amount to 55 events and 163 hours over the interval. Again, these top two tiers are associated with more extreme weather conditions and carry the greatest risks if the energy system does have the capacity and duration characteristics to reliably serve load. Reliable four-hour resources are useful at or above the 1,150 level, such as the existing Basin Creek gas plant. Basin Creek's minimum duration is considered as four hours; however, longer periods of generation are feasible with available fuel supply. This might not be true of other storage resources that have limited production or are affected by environmental factors.

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[29] The long duration resources are listed in Volume 2.

Table 6-4. **Duration Analysis of Net Load**

Net Load (retail load – renewables)					
	Load Level (MW)				
	800	900	1,000	1,100	1,150
Number of events exceeding load level	899	474	224	45	10
Longest event (hours)	91	18	15	9	4
Total hours at or above	6,873	2,973	1,032	142	21
% of 5 year interval	15.68%	6.78%	2.35%	0.32%	0.05%

This analysis underscores the importance of the duration attribute of energy resources in supply planning. Resources in NorthWestern's portfolio can be classified as either long or short duration (Volume 2, section 6.4). Wind and solar resources are variable in nature and are categorized as short duration. Hydro, gas, and coal assets, in contrast, can generate reliably for long periods of time and are categorized as long duration resources. NorthWestern's existing long duration resources sum to approximately 800 MW, coinciding with the first load level explored in this duration analysis. Above 800 MW NorthWestern currently lacks long duration resources and must rely on market contacts and both day-ahead and hour-ahead purchases. However, NorthWestern is taking steps to improve its capacity and duration attributes above this level. Specifically, YCGS's contribution of approximately 168 MW will expand the portfolio's long duration capacity beyond the 900-MW level, beginning in 2024. Then, in 2026, the Colstrip acquisition will provide important long duration capacity to the top of the observed load range, when other resources are often scarce and market prices are high. The Colstrip acquisition will allow Northwestern to reliably serve load levels at and above 1,150 MW and provide a buffer against future load growth and extreme events. At or above the 1,150-MW level, additional accredited capacity shortfall could be met with shorter duration resources provided the existing long-duration resources remain in the portfolio.

7. Transmission System

7.1. Electric Transmission System - Chapter Overview

NorthWestern's transmission system comprises approximately 6,900 miles of 500 kV, 230 kV, 161 kV, 115 kV, and 100 kV systems that connect the various load centers in the state as well as 50 kV and 69 kV systems that serve many local areas. This transmission provides vital reliability service within Montana, and also connects with Montana's neighboring regional markets. The most important interconnections to these markets, discussed below, are Paths 8, 18, 80, and 83.

NorthWestern's Balancing Authority (BA) peaks in both the summer and winter. In 2022, its initial winter peak was set in February at 1921 MW, and its summer peak was set in August of 1977 MW. During these peak events, NorthWestern's BA imported approximately 50% and 38% of its needs, respectively. A new winter peak was set in December at 2073 MW for two consecutive hours during Winter Storm Elliot. During this event, NorthWestern's BA imported approximately 47% of its needs. Table 7-1 shows this peak information as well as the corresponding NorthWestern retail load.

While there is a correlation between when the BA load and NorthWestern's retail load reach their peaks, they are not always on the same hours or days. For example, the NorthWestern BA peak hours on February 23, 2022, and August 1, 2022, were not the NorthWestern retail load peak hours.

Table 7-1. **Peak Loads and Imports 2022**

2022 Peak Hours (Mountain Time)	Total BA Load	Total BA Imports	NWE Retail Load	NWE Market Purchases
Winter 2/23/22 HE8	1921	953 (49.6%)	1138	539 (47%)
Summer 8/1/22 HE17	1977	743 (37.6%)	1239	256 (21%)
Winter 12/22/22 HE19[30]	2073	983 (47.4%)	1194[31]	536[32] (45%)

NorthWestern transmission serves 28 network customers[33] in addition to NorthWestern Supply. Network customers represent about one-third of the loads in NorthWestern's BA Area. These customers include electric supply choice customers, electric cooperatives, and federal power marketing agencies.

NorthWestern also provides point-to-point (PTP) service under its Open Access Transmission Tariff (OATT), as approved by FERC. Currently, NorthWestern has about 30 PTP customers that are very active on NorthWestern's transmission system. Both short-term and long-term (i.e. yearly) PTP sales have grown in recent years. The utilization of NorthWestern's transmission along with external regional systems for inter-regional transfers has contributed to increasing congestion and reduced the amount of available transfer capability (ATC) on NorthWestern's system. While NorthWestern has not studied the causes of the increase in PTP sales, NorthWestern has experienced increased long-term sales on Path 18 into Idaho and Path 8 to the Bonneville Power Administration's (BPA) system. The PTP sales on Path 8 are impacted by the Montana Intertie agreement, which is expiring in 2027.

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[30] Only HE 19 is reported for the December 22, 2022, event even though HE 18 was also a BA peak load hour of the same magnitude.

[31] The actual retail load value was not available at the time of the IRP publication. The value presented here is the day-ahead forecast value. NorthWestern expects the actual retail load value to be higher than the day-ahead forecast.

[32] The actual market purchases value was not available at the time of the IRP publication. The value presented here is the day-ahead forecast value. NorthWestern expects the market purchases value to be higher than the day-ahead forecast.

[33] The network customers and their load amounts are listed in Volume 2 and are available on OASIS at http://www.oatioasis.com/nwmt/ under Network Resource > List_of_Current_Network_Resources.

Peak loads in NorthWestern's BA have grown considerably over recent years and certain areas on the transmission system are experiencing capacity constraints. Peak loads for both residential and small commercial customers have increased with the population growth of the communities served by NorthWestern. This increase in load has escalated following the COVID-19 pandemic with more customers working from home. Both NorthWestern's retail load and cooperative loads reflect this increase. The large commercial and industrial loads have remained relatively consistent over the last three years. However, there continues to be great interest from potential new Choice customers about interconnecting large transmission level loads such as data centers. As described below, the Billings, Butte and South of Great Falls areas are severely constrained and will require additional capital improvements to the transmission system to maintain reliable load service. In addition, the closure of Colstrip would have a significant effect on the transmission system (this is discussed in more detail below).

7.2. Key Definitions

Below are key definitions regarding NorthWestern's transmission system.

- Open Access Transmission Tariff (OATT): the tariff on file with FERC that provides for non-discriminatory access to FERC-jurisdictional transmission systems, such as NorthWestern's, to all eligible customers.
- Total Transfer Capability (TTC): total designed and approved transfer capability of a transmission path.
- Available Transfer Capability (ATC): available transfer capability is the amount of transfer capability left after taking into account the amount of firm commitments of the Transmission provider.
- Reliability: adequacy and security of the transmission system to operate properly under stressed conditions.
- Balancing Authority: The responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time.
- Balancing Authority Area: The collection of generation, transmission, and loads within the metered boundaries of the Balancing Authority. The Balancing Authority maintains load-resource balance within this area.

7.3. The Colstrip 500 kV Transmission System

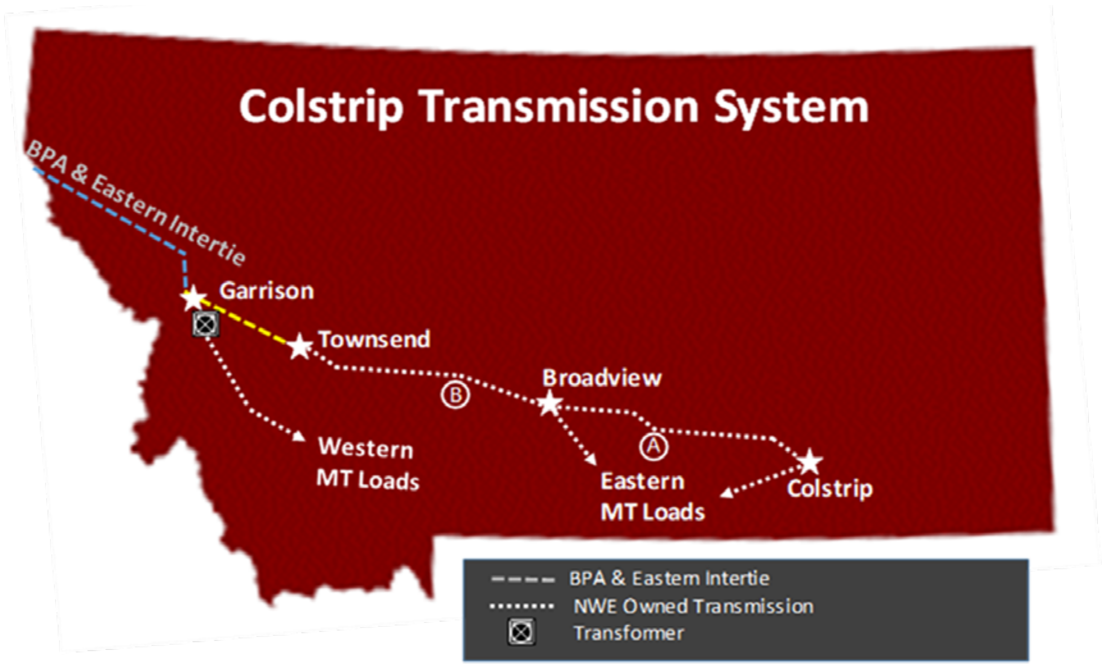
Today, the 500 kV Colstrip Transmission System (CTS) is the backbone of the Montana transmission system, and it provides NorthWestern with a very strong path across the state to reliably serve all Montana customers. The CTS provides strong ties between the lower transmission voltage systems in the state at three substations – Colstrip, Broadview, and Garrison as shown in Figure 7-1.

The CTS runs 248 miles from the Colstrip transmission substation to just south of Townsend, Montana. The CTS is comprised of two 500-kilovolt ("kV") segments. The first segment runs from Colstrip to Broadview. The second segment runs from Broadview to Townsend where the CTS interconnects with BPA's Eastern Intertie.

It is also important to note that there is no substation at Townsend. The ownership and construction type changes at this point. NorthWestern contracts for firm transmission rights on the Eastern Intertie, in order to continue to deliver energy further west from Townsend to the BPA Garrison substation. The Garrison substation is also critical to NorthWestern as it is the largest contributor to the overall transmission interconnection to the West allowing for both import and export from and to the regional market. In addition, NorthWestern interconnects at Garrison with 230 kV facilities adding another strong path to serve customers in western Montana. The CTS and the BPA Eastern Intertie are operated as one facility and are both within NorthWestern's Balancing Authority Area (BAA).

The CTS provides the greatest access to and from the regional market in the Pacific Northwest. Access to these markets west of Montana is extremely important to allow NorthWestern to import power into Montana from large energy markets located in the Columbia River region (Mid-C). This import capability has received significant increased use as Montana's thermal generation retires and peak loads in Montana continue to grow.

Figure 7-1. General Location of the Colstrip Transmission System and BPA's Eastern Intertie.



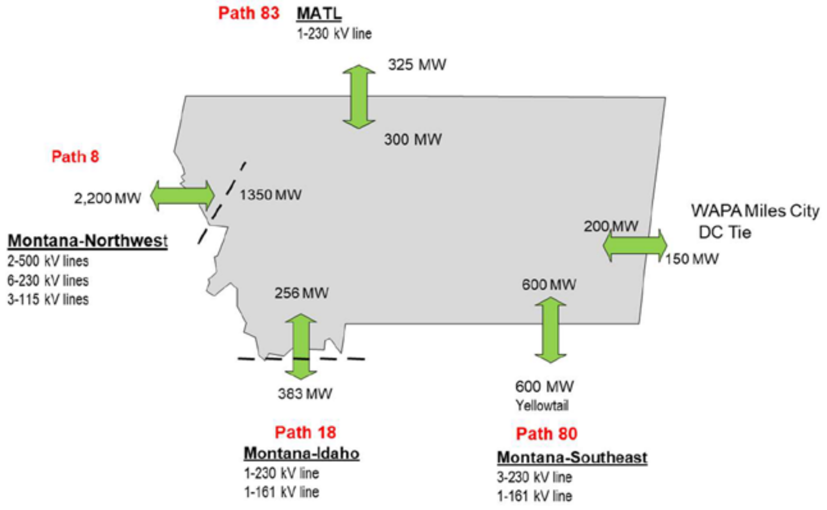
The CTS is critical to NorthWestern and its customers because it is fully integrated into NorthWestern's transmission system and contributes to reliability through the balancing of resources and loads. The CTS serves the critical role of providing for both exporting energy from Montana and importing energy into Montana.

From a historical perspective, the 500 kV transmission lines were primarily constructed to export a portion of the Colstrip-generated power to load centers in Washington and Oregon and, importantly, to tie NorthWestern's lower voltage transmission system to the 500 kV transmission system from east to west across Montana adding significant reliability benefits and assisting NorthWestern in supplying energy to western Montana loads. These lines provide NorthWestern with the added benefit of vital access to the regional market that is necessary to import power into Montana to serve customers. In addition, the CTS is fully integrated into NorthWestern's transmission system and Balancing Authority. The CTS and BPA Eastern Intertie are fully integrated and operated as one system.

7.4. Transmission Interconnections with Other BAs

Figure 7-2 below depicts the amount, as rated by WECC, of TTC at the major interconnections of NorthWestern's system with other transmission systems. NorthWestern does not own all the transmission capacity (TTC) shown on these paths. Since NorthWestern does not own the transmission capacity, the capacity is not necessarily available to NorthWestern Supply to import energy onto the system to address peak loads. Further, there may not always be generating capacity outside of the BA available for import at the same time there is transmission capacity available. In other words, to import energy onto NorthWestern's system, there must be simultaneous generation capacity and transmission capacity. Consequently, relying solely on imports is a risky and expensive approach to addressing supply capacity shortages.

Figure 7-2. NorthWestern Path Interconnections to WECC[34]



7.5. Electric Transmission System Physical Constraints

7.5.1. Interconnection Transmission Paths

This section explains the constraints on the paths that make up the interconnection between NorthWestern's BA and external entities. Transmission lines are constrained by stability, voltage, and thermal limits. Transmission system operators, like NorthWestern, use transmission line ratings to ensure that flows on transmission lines do not create risks of reliability events or damage to lines or equipment.[35] In general, the issues that affect each of NorthWestern's interconnection paths fall into one of two categories: voltage and thermal limits. Voltage violations and thermal violations tend to occur when too much power goes through an undersized system. Voltage violations indicate that voltage on the system is below an acceptable level. These violations could be widespread, or localized to a particular area. Thermal violations indicate that a transmission element has reached its thermal rating. Violations can occur when all lines are in service ("steady state"), or after an outage on the system ("post-contingency"). Voltage and thermal violations are not mutually exclusive and can cause other unwanted effects on the system that impact end-use customers and generators (such as transient instability).

7.5.1.1. Path 8 – Montana to Northwest

Path 8 consists of two 500 kV lines, six 230 kV lines, and three 115 kV lines. The two 500 kV lines (Broadview to Garrison) are part of the jointly owned CTS. The east-to-west (export) rating of Path 8 is 2200 MW. Path flows greater than the established rating could cause voltage violations and/or thermal violations depending on transmission outage conditions. The east-to-west (export) rating is currently protected by a Remedial Action Scheme (RAS) that will automatically take corrective actions by shedding generation interconnected at Colstrip. In order to achieve a higher export, the transmission system would need upgrades on both NorthWestern's system and the neighboring BPA transmission.

The west-to-east (import) rating on Path 8 is 1350 MW, and the TTC varies by season based on loading in the Flathead, MT area. Power flows greater than the established path rating could cause voltage violations and/or thermal violations depending on transmission outage conditions. An increase in Path 8 import capability and ATC would likely require reinforcements to either NorthWestern's and BPA's 230 kV transmission system or a new line interconnecting to BPA. It is unknown at this time if any upgrades would be required by Avista or BPA to allow increased transfers into Path 8.

A major part of Path 8 is the CTS and BPA's Eastern Intertie shown in Figure 7-1. To be clear, however, while critical, the ability to import on the Eastern Intertie and the CTS is limited. This will be discussed in more detail below in Section 7.6 Available Transfer Capability. Finally, the contract with BPA that governs rates and available capacity on the Eastern Intertie, the Montana Intertie Agreement, terminates September 30, 2027. BPA has begun a process to determine what capacity will be available on the Eastern Intertie and at what rates beyond September 2027. As a result, there is uncertainty regarding Path 8 capability in the future.

7.5.1.2. Path 18 – Montana to Idaho

Path 18 consists of one 230 kV line and one 161 kV line in southwest Montana. Primary flows on Path 18 are in the north-to-south (export) direction. The TTC and rating of Path 18 is 383 MW in the southbound (export) direction and 256 MW northbound (import). Path flows greater than the established rating could cause thermal violations on the Mill Creek 230 kV phase shifting transformer. A phase shifting transformer is a device that acts like a valve to control power flow down a particular transmission line. In the case of Path 18, the Mill Creek phase shifting transformer allows NorthWestern to moderately control the power flow on the 230 kV line. The phase shifting transformer is critical to Path 18 operation. There are also outage conditions in Idaho and Wyoming that prevent Path 18 from exceeding 383 MW southbound. These outages can cause low voltage violations along the path. In order to increase the path rating and TTC in the southbound direction, upgrades may be required including a new phase shifting transformer at Mill Creek, transmission reinforcements in southwest Montana to relieve voltage violations, and/or transmission line upgrades.

The south-to-north rating of the path (256 MW) is limited by the outage of the 230 kV Antelope to Brady (Idaho Power) line which would overload the Antelope to Goshen 161 kV (PacifiCorp) line. To prevent overloads on the line, a RAS has been installed to open up the south end of 230 kV portion of the path. Following the opening of the line, low voltage can occur in southwestern Montana and the RAS is in place to prevent any violations from occurring. In order to achieve higher imports on the path, upgrades on PacifiCorp's system and/or voltage reinforcements in NorthWestern's system may be necessary.

7.5.1.3. Path 80 – Montana Southeast

Path 80 consists of three 230 kV lines and one 161 kV line in southeastern Montana to northern Wyoming and the Western Area Power Administration (WAPA) and PacifiCorp's (PAC) systems. The primary direction of flow is from north-to-south and the three lines that terminate at Yellowtail, MT are all controlled by phase shifting transformers. The tie at WAPA's Crossover substation also has a connection to the Miles City DC line that transfers power to and from the Eastern Interconnect.

Path 80 is rated to 600 MW for both north-to-south (export) and south-to-north (import) flows. However, in actuality the transfer capacity on Path 80 is often significantly lower due to transmission constraints in both Montana and Wyoming. The factors that limit Path 80 exports can include Miles City DC flow, system loading in the Billings area in NorthWestern's system, and Yellowtail generation. The actual limit may be much less depending on those variables. The path is also constrained by the transmission system south of Path 80 at Yellowtail South as well as transmission in Wyoming that make up Paths 38 and 85 (TOT 4A & 4B). For these reasons, Path 80 can be an unreliable path at peak and other times for firm transfers. In order to increase path capability in the north-to-south direction, major transmission upgrades would be necessary in both Montana and Wyoming.

Like the north-to-south limits, the south-to-north path rating (600 MW) faces limitations that can result from Miles City DC flow and Yellowtail generation. In order to increase path capability in the south-to-north direction, similar transmission upgrades would be necessary in both Montana and Wyoming. Again, due to congestion and limitations discussed, Path 80 can be unreliable during peak and other times for firm transfers.

7.5.1.4. Path 83 – Montana Alberta Tie Line (MATL)

Path 83 consists of a single 230 kV line that connects Montana to Alberta, Canada. The path is rated at 325 MW southbound and 300 MW northbound. Path 83 flows cannot exceed the established ratings without causing a thermal violation to the phase shifting transformer at the north end of the path. Additionally, Path 83 is often limited by constraints in NorthWestern's system on the South of Great Falls path (discussed below).

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[34] Path 8 imports to NorthWestern can be less than shown based on a nomogram.

[35] FERC provided a discussion of the fundamentals of transmission line ratings in its January 21, 2021 Notice of Proposed Rulemaking in FERC Docket No. RM20-16-000 found at: https://www.federalregister.gov/documents/2021/01/21/2020-26107/managing-transmission-line-ratings

7.5.2. Internal Transmission System

Internal network capacity on NorthWestern’s transmission system is currently reaching its limits, which could impact load service and reliability in the near future. This section discusses some of NorthWestern’s key concerns and what it is doing about those concerns.

7.5.2.1. Billings Area

Billings is primarily fed by two 230 kV lines from the north. It also has two 230 kV lines connecting from the southeast that tie to Path 80 (see Figure 7-1), as well as a 230 kV and 161 kV line that head west to feed Bozeman. Billings and Path 80 are currently limited by the two 230 kV lines from the north as that is the predominate path that feeds both the Billings area and Path 80.

As loads grow, the ability to serve load in Billings and allow flow down Path 80 on a firm basis is diminishing. Even with zero MW of firm commitments down Path 80, the Billings area transmission system is currently challenged under peak loading conditions. System improvements in the Billings area are needed in the near future to continue to serve load in the Billings area. System improvements could include, but would not be limited to, new transmission, new substation facilities, or new generation. Some of these transmission/substation improvements are underway already, while others are planned. YCGS will also be critical for continued reliable service to Billings from a transmission perspective, along with the other transmission and substation upgrades in the area.

7.5.2.2. Butte/SW Montana Area

Butte/SW Montana has similar constraints as Billings. Butte is primarily served by two 230 kV lines from the north. It also has a 230 kV and 161 kV connection that heads east to feed Bozeman as well as a 230 kV and 161 kV connection that heads south and makes up Path 18 (see Figure 7-1). The Butte Area and Path 18 are currently constrained by the two 230 kV lines from the north.

As load in the Butte area grows, the reliability in the area and firm transmission on Path 18 are diminishing. System improvements in the Butte area will be needed in the near future to continue to serve NorthWestern load as well as allow use of Path 18 on a firm basis. System improvements could include, but would not be limited to, new or reconstructed transmission lines, new flexible generation and/or new firm imports across Path 18.

7.5.2.3. South of Great Falls

South of Great Falls is an internal path on NorthWestern’s transmission system that consists of two 230 kV lines and five 100 kV lines. The underlying 100 kV system is the primary limitation on the path because of the consequences that would occur with the loss of a single 230 kV line.

The constraints on South of Great Falls severely limit the ability to schedule power to and from the Montana Alberta Tie Line (MATL), which makes up Path 83, as well as the ability to move power from generation in the Great Falls and surrounding area. NorthWestern has a 10-year power purchase agreement in place that is utilizing most of the remaining transmission capacity on the South of Great Falls path. In order to accept any new transfers across this part of the system or new generation in the area, new and/or upgraded transmission will be necessary.

7.6. Available Transfer Capability

The Available Transfer Capability (ATC) is the transmission that is available for customers’ use after considering existing rights and obligations. Figure 7-3 below is the current snapshot of long-term ATC at each of NorthWestern’s interconnections with other systems. Yearly Firm ATC on Paths 8, 18, and 80 for the next several years is also listed in Table 7-2 below. ATC is the critical value for determining transmission capacity available for reliable operation. ATC is much less than TTC and can change from time to time. There is also competition for ATC from multiple types of transmission customers.

Figure 7-3. The TTC and ATC for Transmission Paths that Interconnect the NorthWestern System with the Rest of the Western Interconnection.

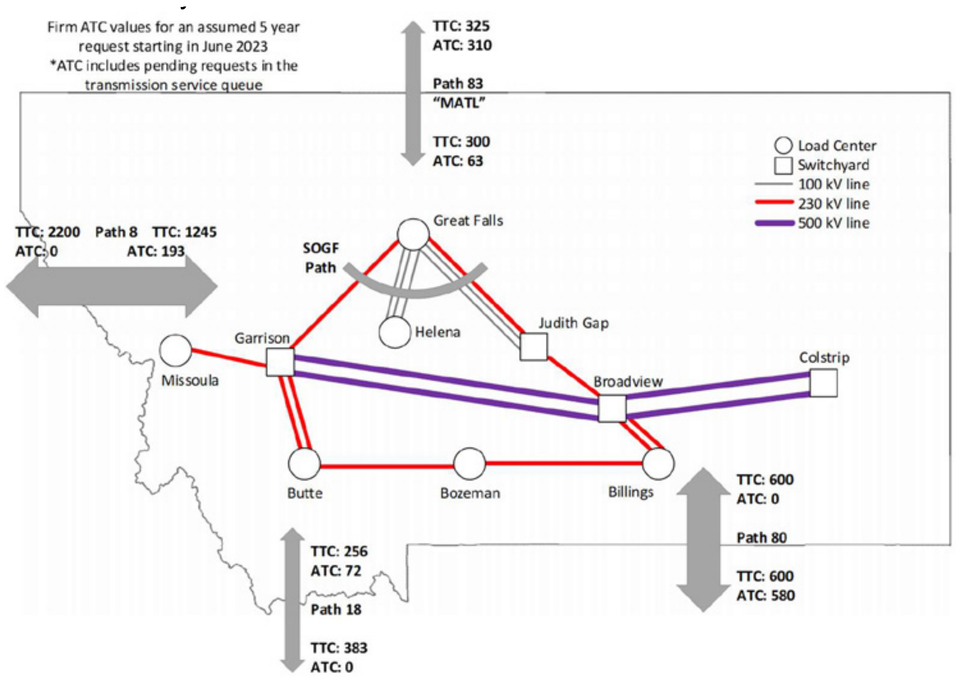


Table 7-2. Firm ATC for Paths 8, 18, and 80 from 2023 through 2025.

Yearly Firm ATC by Year (as of 2/23/2023)		
Path 8	*BPA Import*	**Yearly Firm ATC**
	2023	**0**
	2024	**31**
	2025	**47**
	AVAT Import	
	2023	**196**
	2024	**162**
	2025	**162**
Path 18	*BRDY Import*	
	2023	**59**
	2024	**59**
	2025	**0**
	Jeff Import	
	2023	**72**
	2024	**72**
	2025	**72**
Path 80	*YTP/Crossover Import*	
	2023	**0**
	2024	**0**
	2025	**0**

NorthWestern, under its FERC Open Access Transmission Tariff, is required to provide transmission service to several types of customers, which means that there is significant competition for ATC among many potential users of the transmission system. NorthWestern’s transmission system serves four types of customers – retail, network, interconnection, and point to point (PTP). In addition to NorthWestern’s retail customers, our FERC customers include electric cooperatives, federal marketing agencies, and “choice” customers, who are customers that do not receive their supply service from NorthWestern.

This means that there are many non-NorthWestern entities within the NorthWestern BA that are competing for available transmission, constraining transmission of power at critical peak times when customers need that power the most. This transmission competition is becoming much greater as in-state generation is shut down. It is important to note that transmission capacity is awarded on a first-come, first-served basis and that native load does not receive any preference over other eligible customers. In addition, there are rules governing what is a valid transmission service request or network service designation. For example, long-term network transmission service designation requests must be tied to legitimate network resources with valid contracts for service in place. Table 7-3 displays the current firm transmission that is reserved on a long-term basis by parties. Many of these reservations are not for service to NorthWestern's customers. This transmission capacity is reserved under NorthWestern's FERC OATT, which includes point-to-point customer wheeling into and out of NorthWestern's system, and Network customers, including some reservations by NorthWestern, importing energy from outside of Montana and into NorthWestern's transmission system to serve load.

Table 7-3: **Long-term Firm Reservations by Customer Type (MW)**

Long Term Firm Reservations from Import Interface Paths (as of 01/27/2023)				
	Path 8 Imports	Path 83 Imports	Path 80 Imports	
Network	690	225	37	
Point to Point	342	0	31	
Total	1032	225	68	1325

7.7. Loss of Colstrip Analysis

With the future of Colstrip coal-fired generation in question, NorthWestern analyzed potential impacts to the transmission system that could result from the complete loss of Colstrip. The primary objective of this study was to determine whether imports from off-system resources could be utilized for a replacement of Colstrip generation serving Montana load. The study also analyzed the minimum operable generation in NorthWestern's BA, which is a limit of how much generation NorthWestern needs inside the BA to operate reliably on any given day.

With the complete retirement of Colstrip power plant, NorthWestern would have to procure power to serve load from somewhere else. A possible source of replacement power could be located outside of NorthWestern's BA and imported on one of the paths described above. NorthWestern's Electric Transmission Planning group analyzed the use of imports from off-system resources to make up for the lost supply. Paths 8 and 18 were assumed to provide the majority of the imports as they were deemed the most liquid and reliable import paths. However, there is no guarantee that off-system purchases can be made, and there is no guarantee that transmission capacity is available to reliably import off-system purchases as described above in Section 7.6 above.

NorthWestern's analysis concluded that imports from off-system resources cannot control voltage in the same way that the generation at Colstrip can control voltage, and an immediate loss of Colstrip would create high voltage problems on the transmission system. An installation of reactors would be required to mitigate this high voltage. The reactors are necessary because the high voltage issues cannot be resolved through operational mitigation. NorthWestern's Electric Transmission Planning Group estimated that the necessary reactors would require an investment of $20-30 million. Currently, Colstrip is able to maintain the voltage on the CTS reliably. Without any generation on the CTS (to replace the lost generation at Colstrip) to control the voltage, the high voltage from the CTS trickles down to the lower voltage system across the state. Replacing the voltage stability provided by Colstrip would be difficult, perhaps impossible, to do with off-system generation because of the limited capability of off-system resources to control voltage remotely. From a long-term perspective, NorthWestern's Transmission function does not believe that reliance on off-system imports to completely replace the energy in the BA associated with Colstrip is a reliable or realistic assumption. This determination is supported by the Loss of Colstrip study, which is included in Volume 2 of the Plan.

8. Resource Planning and Analysis

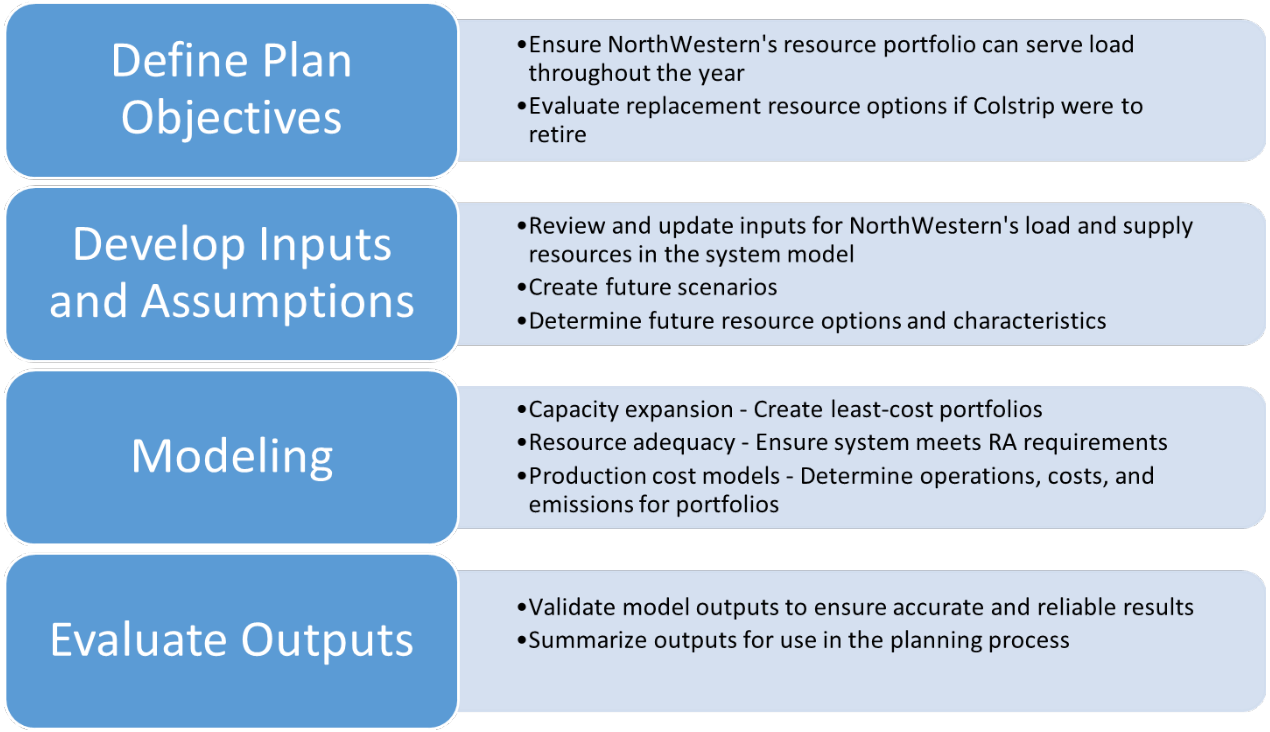
8.1. Introduction

In developing this Plan, NorthWestern relied on a series of models to analyze the system needs and develop a roadmap towards meeting those needs under a variety of future scenarios. This chapter describes the approach, assumptions, results, and implications of the modeling performed by NorthWestern for the Plan. All modeling and analysis work took place in the PowerSIMM modeling environment. Modeling was performed between April 2022 and March 2023.

8.2. Analytical Method

In the development of this plan, the modeling team followed the process outlined in Figure 8-1. The analytical process consisted of defining the modeling objectives, developing the inputs and assumptions used in the models, running the models, and evaluating the outputs. The end result is a set of portfolios best aligned to meet NorthWestern's energy and capacity needs over the next twenty years for different future scenarios. In each scenario the best portfolio is defined as the mix of supply resources that can satisfy NorthWestern's needs at the lowest possible cost.

Figure 8-1. **Modeling Process**



NorthWestern constructed the capacity expansion model by constructing candidate resource options for the resource algorithm. Candidate resource configurations require inputs defining the capacity value of the resource, capital cost, annual fixed costs, number of units that can be built annually, in addition to the technical specifications of the resource. In addition to the candidate resources, NorthWestern configured model constraints that defined system needs such as annual capacity requirements and annual energy needs.

Capacity requirements in the WRAP are set monthly for each member based on annual resource adequacy studies. NorthWestern's requirements for winter and summer months are shown in Table 8-1.

Table 8-1. WRAP Assigned PRM Values for NorthWestern in 2023

Winter		Summer	
Month	**PRM**	**Month**	**PRM**
November	21.6%	June	16.5%
December	17.7%	July	10.4%
January	19.0%	August	10.3%
February	19.9%	September	17.9%
March	26.9%		

Historically, winter peaks occur between December and February while summer peaks occur in July or August. To simplify the capacity expansion model, the team used a winter and a summer capacity requirement and set the planning reserve margins to 20% for winter and 11% for summer based on the fact that historical winter peaks generally occur between December and February while summer peaks occur in July or August. The values used in the model were based on the table above and rounded up to provide a slightly more conservative estimate for future years.

The energy constraint in PowerSIMM was limited to no more than 150% of load. This constraint is meant to limit NorthWestern's exposure to market price risk leading to little or no revenue from excess generation from variable resources. The energy constraint restricted the level of variable resource selection in the model which may depress prices at LMPs in NorthWestern's territory and cause NorthWestern to either sell the excess generation at a loss or curtail it.

Capacity expansion models provide a least-cost set of resources that meet the constraints defined in the model. Portfolio outputs from the capacity expansion models are checked for resource adequacy based on the WRAP requirements for NorthWestern. If a portfolio cannot adequately serve load, additional resources must be added. Finally, portfolios are evaluated in a production cost model where they are analyzed to determine production costs, emissions, and market interactions, among other outputs.

Once all the input assumptions are defined, the NorthWestern modeling team developed an initial list of scenarios and sensitivities. Scenarios are core frameworks for possible future portfolios, and sensitivities are variations on the scenarios to test how changing assumptions affect the indicated least-cost resource and production cost. The core scenarios revolve around early retirement dates of Colstrip from the current scheduled retirement date of 2042 to as early as a 2025 retirement.

8.3. PowerSIMM Model Framework

NorthWestern licensed PowerSIMM, developed by Ascend Analytics, for the modeling work in this analysis. PowerSIMM provides capacity expansion, resource adequacy, and production cost modeling. NorthWestern employed stochastic models to capture variability and uncertainty in load, renewables, and prices while maintaining structural parameters among the variables.

PowerSIMM simulations rely on historical data for weather, renewable generation, load, and market prices to create realistic future simulations. Simulations are scaled to future expectations based on monthly forecasts for renewables, load, and prices and incorporating expectations of price volatility and daily price shapes. The result is a set of simulations covering a useful and accurate range of potential future paths.

Automated Resource Selection (ARS) is PowerSIMM's capacity expansion module. ARS indicates the least-cost resource procurements or retirements which satisfy the model constraints. The models begin with a dispatch of existing and candidate resources to determine variable costs, energy generation, carbon emissions, and renewable generation over the time horizon of the study. NorthWestern employed the following model constraints:

1. **Reserve Margin** – Requires portfolio to meet annual peak demand plus seasonal reserve margins of 11% in summer and 20% in winter based on the WRAP assigned PRMs for the year 2023.
2. **Energy Generation** – Requires portfolio to supply no more than 150% of NorthWestern's load to address a balanced approach to market purchases.
3. **Fossil Fuel Resources** – Does not allow new fossil fuel resource additions after 2035, which is consistent with NorthWestern's Net Zero by 2050 goals.
4. **Resource Build Limits** – Prohibits resource builds before 2027. Based on previous resource acquisitions, new resource construction and permitting times would take until 2027 if NorthWestern initiated an RFP in 2024.

NorthWestern used capacity and energy constraints in the ARS model as a way to limit physical risks of not meeting load and financial risks associated with substantial over generation. The ARS price simulations follow a forecast and do not adjust with local increases in energy production. If NorthWestern were to generate substantially more energy than it consumes, market prices would likely drop to near or below zero which removes any potential market benefits for customers. Price depression at NorthWestern's LMPs from excessive wind or solar is likely with the high amount of wind and solar expected to come online over the next few years through the QF process. The Southwest Power Pool (SPP) and CAISO are prime examples of market price depression due to excessive renewable generation from wind (SPP) or solar (CAISO). As a participant in the W-EIM, NorthWestern is paid the LMP for generation dispatched to that market. The ARS energy constraints limit the total energy generation to 150% of load as a method to avoid significant over generation with no benefits.

Outputs from ARS provide the timing and quantity of resources to procure through the time horizon which satisfy the above constraints at the lowest cost. The model considers full resource costs including capital costs, fixed costs, and variable costs (fuel, variable O&M, startup costs). Market sales revenue is treated as a negative cost in the model.

The next stage of the planning process is to evaluate ARS output portfolios in resource adequacy models. If a portfolio is capacity deficient, ARS is rerun with adjusted inputs to the portfolio to meet resource adequacy requirements.

Finally, the portfolios were evaluated in production cost models to calculate generation costs including fuel costs, startup costs, variable O&M, fixed costs, and revenue requirements. In the early Colstrip retirement scenarios, undepreciated capital costs are assumed to continue depreciation until 2042. Aside from generation costs, production cost modeling also provides outputs for carbon emissions, market purchases and sales of power, and operational characteristics of the dispatchable resources like capacity factors.

8.3.1. Candidate Resources

In addition to NorthWestern's existing resource portfolio, this Plan considers the following candidate resources for new resource portfolio additions (Table 8-2). The list of candidate resources was established to consider a broad array of new resource technology types and sizes for possible inclusion in portfolio modeling across various modeling sensitivities. The following provides a brief overview of the candidate resources and associated sizes considered. All thermal resources considered are based on the use of natural gas fuel only.

- Wind – New candidate wind resources are assumed to be located in Montana and have capacity factors in the 40% to 45% range. Wind cost for 2023 is projected at $1,764 per kilowatt (kW) based on wind farms in the 300 MW size.
- Solar Photovoltaic (PV) – New candidate solar resources are assumed to be single-axis tracking with capacity factors in 20% to 25% range. Solar cost for 2023 is projected at $1,662 / kW based on 300 MW-sized solar installations.

- Battery Energy Storage Systems (BESS) – BESS storage durations of 4 and 8 hours were considered. The BESS candidate resource costs are based on lithium-ion chemistry, daily BESS cycling (up to 365 cycles per year) and capacity augmentation throughout the resource lifecycle. In 2023, the projected four-hour duration cost is $1,984 / kW, and the eight-hour cost is $3,576 / kW.
- Pumped Hydro Energy Storage (PHES) – A 100 MW, 8-hour closed-loop PHES resource assumed to be a portion of a larger PHES installation. The cost of the PHES in 2023 is assumed to be $3,561 / kW.
- Simple Cycle (SC) Combustion Turbines (CTs) – A nominal 50 MW aeroderivative CT with operations and maintenance cost estimates based on approximately 1,000 hours of operation per year with a capacity factor near 15%. The 2023 cost of a new resource is assumed to be $1,867 / kW.
- SC Reciprocating Internal Combustion Engines (RICE) – An 18 MW unit was configured in the model. Cost projections assume roughly 1,000 hours of operations per year and that multiple units are co-located for economies of scale. In 2023, the assumed capital cost is $1,719 / kW.
- Combined Cycle (CC) CT – A nominal 250 MW CCCT with operations and maintenance costs estimated based on approximately 4,000 hours of operation per year. The dispatch of combined cycle resources generally varies between 30% (intermediate dispatch) up to 80% to 95% (baseload resource). The cost is projected to be $1,640 / kW in 2023.
- Small Modular Reactor – An 80 MW fourth-generation nuclear reactor that can be assembled with four units for a total plant size of 320 MW. Reactors are assumed to have high capacity factors, above 90%. Capital costs for 2030 and beyond are projected to be $3,600 / kW based on a 320 MW configuration.

Table 8-2. Summary of Candidate Resources Considered in this Plan.

Technology/ Fuel	Resource	Incremental Size in the Model (MW)	2023 Overnight Cost ($/kW)	Fixed O&M ($/kW-yr)	Variable O&M ($/ MWh)	Hourly Cost ($/hr)
Renewable	Wind	50 MW	$1,764	$33.41		
	Solar	50 MW	$1,662	$20.76		
Storage	Battery Storage (4-hour duration)	25 MW	$1,984	$27.50		
	Battery Storage (8-hour duration)	25 MW	$3,576	$54.24		
	Pumped Hydro (9-hour duration)	100 MW	$3,561	$17.47	$1.08	
Natural Gas	Aeroderivative gas turbine	50 MW	$1,867	$19.32	$0.48	$250
	Combined Cycle (2x1)	250 MW	$1,640	$18.50	$1.34	$1,000
	Reciprocating Internal Combustion Engine (RICE)	18 MW	$1,719	$17.00	$2.31	$128
Uranium	Small Modular Reactor	80 MW or 320 MW (4 units)	$3,600		$15	

The Inflation Reduction Act (IRA) extended and expanded tax credits for carbon-free generation and energy storage. Due to the IRA, solar now qualifies for the Production Tax Credit (PTC) and the Investment Tax Credit (ITC). Energy storage now qualifies for the ITC as a stand-alone project where storage previously had to charge from a renewable resource to qualify for the credit. It is for this reason that hybrid storage projects were not considered as candidate resources. The IRA tax credits were applied to the candidate resources as shown in Table 8-3. For the wind and solar resources, PTC rebates were estimated based on the projected capacity factors. Resources collect the PTC for 10 years. Therefore, the net present value of the ten years' worth of PTC benefits were subtracted from the capital cost of the resource. Energy storage capital costs were reduced by 30% since storage qualifies for the ITC.

Table 8-3. Tax credits Assumed in the Model Based on the IRA

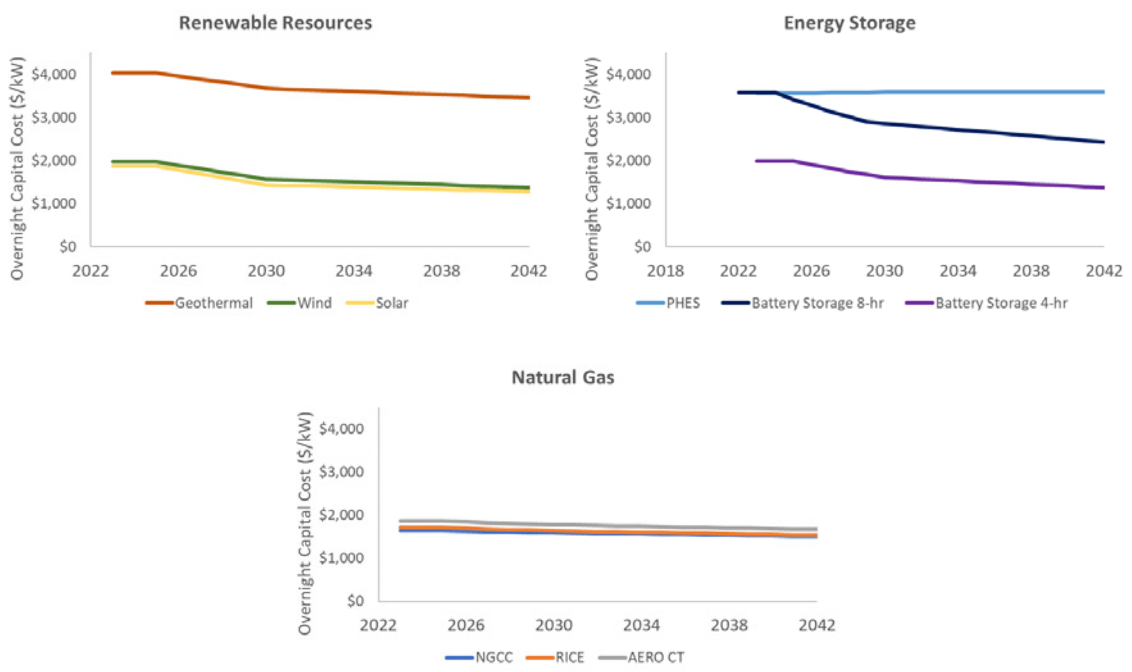
Resource Type	Tax Credit	Notes
Wind	Production Tax Credit	PTC for wind has been extended ten years. The extension is carried through the model period.
Solar	Production Tax Credit	Solar qualifies for the PTC and the ITC, but most utility scale plants will fare better with the PTC.
Battery Energy Storage	Investment Tax Credit	Energy storage no longer needs to charge from a renewable source to qualify for the ITC.
Pumped-Hydro	Investment Tax Credit	Pumped-hydro is treated similarly to battery energy storage.
Nuclear SMR	Production Tax Credit	The PTC is not included for SMRs in the model, but adjustments are made to the outputs to include PTC benefits.

8.3.2. Cost Estimates Process

The development of resource costs included overnight capital costs along with operations and maintenance costs. Capital costs estimates assumed an engineer, procure, and construct contract for the direct resource costs at the project location. Owner's costs for permitting, project development, and NorthWestern costs were estimated as a percentage of the project cost. Indirect costs such as pipeline upgrades or transmission requirements were not included. All cost projections include inflation expectations based on project bid data and feedback from developers. Details of the cost estimate process and assumptions are provided in Volume 2 Appendix F.

Resource costs are expected to decline in the long run after a short-term increase due to current inflation levels. Over time, inflation will subside and technologies will come down in cost with technological improvements. The pace of cost declines depends on the type of resource. Figure 8-2 shows the capacity cost curves used in the ARS models. Note the costs shown do not include variable or fixed costs.

Figure 8-2. Capacity Cost Curves Used in the ARS Models



Variable and fixed costs are included in the models in addition to the capital costs. Wind and solar resources do not have variable costs in the model. Natural gas resources have operational costs added to the capacity costs. Added costs include fuel, start-up costs, and costs for maintenance and operational support.

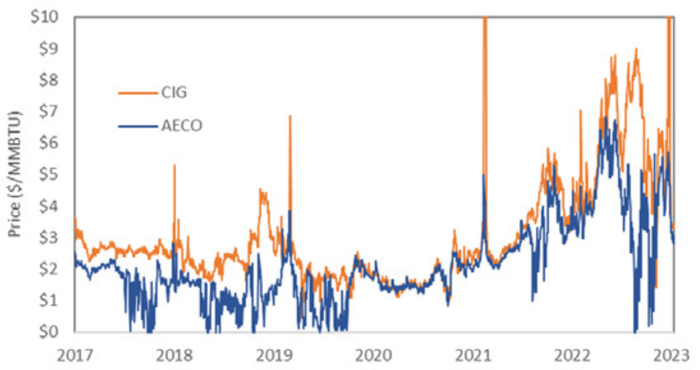
8.4. Commodity Price Forecasts

8.4.1. Natural Gas Prices

Natural gas prices are a key component in any power price forecast and production cost assessment. Figure 8-3 shows the daily spot price history of natural gas at the Alberta Energy Company hub (AECO) and the Colorado Interstate Gas hub (CIG) from 2017 until the end of 2022. The chart shows natural gas prices mostly below $4/million British Thermal Units (MMBTU) prior to 2022 when prices rose above $6/MMBTU.

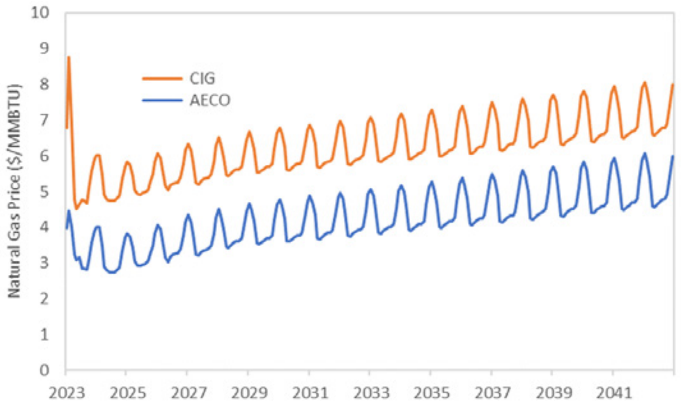
NorthWestern purchases gas from the AECO hub to supply the DGGS and Basin Creek natural gas-fired generation units. However, the pipeline capacity to NorthWestern from AECO is limited so future natural gas generation, including YCGS, is assumed to use gas purchased from the CIG. As shown in figure 8-3, CIG prices have historically been higher than AECO.

Figure 8-3. Historical Natural Gas Prices for AECO (Blue) and CIG (Orange) from Powerdex



The natural gas prices forecast starts with futures prices for AECO hub for the next four years and escalates the prices beyond the four-year strip by an assumed 2% annual increase. Futures prices for the years 2023 to 2026 were sourced from the Intercontinental Exchange. This approach has the benefit of simplicity and its validity rests on the reliance on the collective wisdom of the market over difficult to predict fundamentals. At the time of the forecast, forward prices for CIG were higher than AECO prices. Forecasted monthly prices are shown in Figure 8-4 for AECO and the CIG hub.

Figure 8-4. AECO and CIG Forecasted Monthly Prices



The natural gas forecasts shown in Figure 8-4 represent monthly average gas prices in the model used in the generation of daily price simulations.

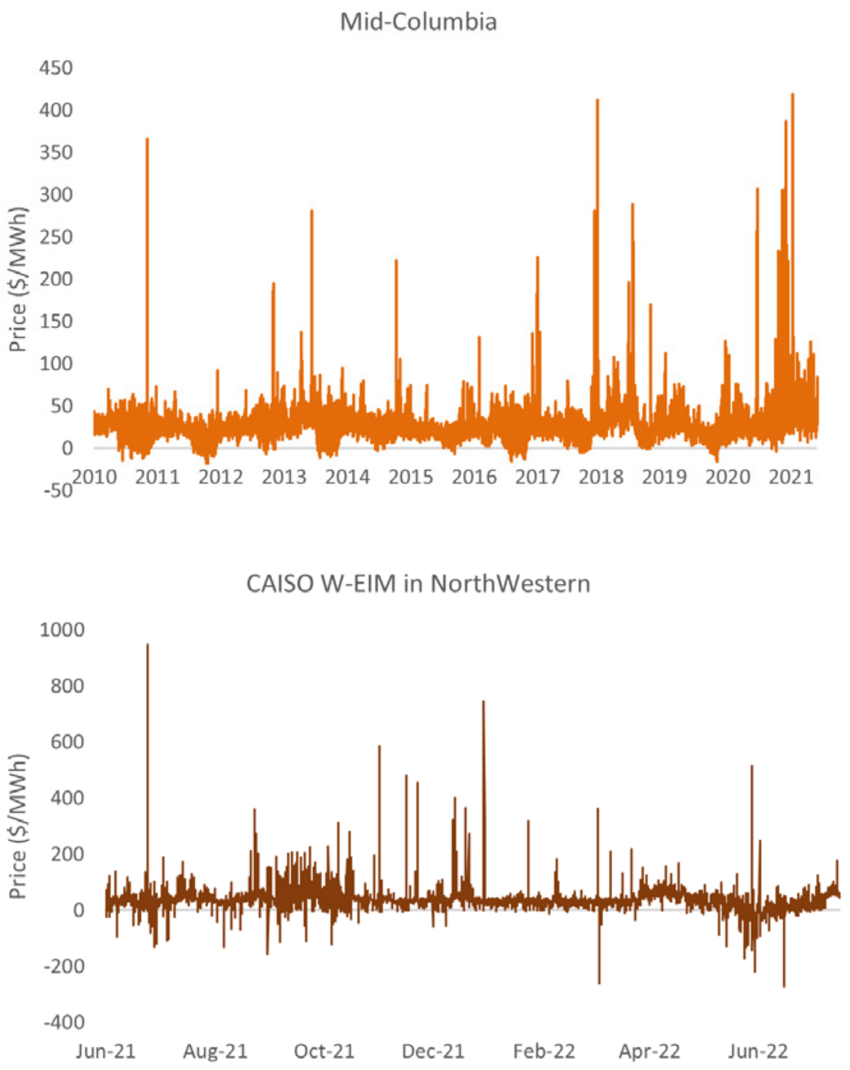
8.4.2. Coal Prices

Westmoreland Rosebud Mining, LLC (Westmoreland) is the owner of the Rosebud Coal Mine, which supplies coal for Colstrip. NorthWestern is a party to the 2020 Coal Supply Agreement with Westmoreland. That agreement contains Westmoreland's competitive pricing information and is confidential under the MPSC's Order No. 7788a. The PowerSIMM model used the annual prices agreed upon in the contract until the expiration date of the contract in 2025. After the contract expiration, coal prices are assumed to escalate at 2% annually to align with future expectations for long-term inflation.

8.4.3. Power Prices

NorthWestern's capacity expansion and production cost models simulate market prices at the Mid-C power trading hub. Prices at Mid-C are used to determine dispatch of contracted resources outside of Montana, and to generate price simulations for nodes in NorthWestern's territory that are part of the W-EIM. NorthWestern joined the W-EIM in June of 2021. A history of the Mid-C prices since 2010 is shown in figure 8-5 along with the W-EIM prices in NorthWestern's load zone since June 2021. W-EIM prices are real-time prices at the five- and fifteen-minute levels. The chart shows price averages over hourly time steps. The W-EIM prices are more volatile with more frequent negative prices and larger price spikes.

Figure 8-5. Mid-C and W-EIM Price History from Powerdex



Power prices are influenced by a range of factors that operate on different timescales. For example, the demand for power follows daily patterns based on residential and business activity and seasonal patterns driven largely by the weather. Demand can also exhibit long-term trends based on population growth, economic trends, or improvements in energy efficiency. Like the demand for electricity, renewable generation is also subject to daily and seasonal variations which must be considered when forecasting prices. The primary inputs into the power price forecast include:

- Forward prices for power. NorthWestern's power price forecast starts with four years of futures prices for power at the Mid-C trading hub. The futures prices were pulled Dec. 20, 2022 for trading periods up to December 2027. Power is priced in blocks of time for light-load hours (nighttime and Sundays) and heavy-load hours (weekdays and Saturdays).
- AECO natural gas price forecast.
- Planned projects and announced retirements. Data taken from resource plans in the region and the U.S. Energy Information Administration (EIA) provide information on the near-term supply for the region.
- State and federal policies affecting generation planning including the recently passed Inflation Reduction Act.

The forward curves from futures market for power are combined with a long-term forecast of Mid-C monthly power prices for heavy load and light load hours based on market fundamentals, Figure 8-6a. Prices start high and drop quickly in the near term as observed in the future market prices for power at Mid-C. The mid-term prices decline with renewable growth until the early part of the 2030s. In the long term, prices rise gradually mainly due to carbon prices in California and Washington. In additional to monthly prices, NorthWestern models included a forecast of price volatility and daily price shapes for the Mid-C trading hub. Figure 8-6b shows price volatility in the Mid-C forecast dataset for one week in February 2025, with the average price represented by the black line. Price volatility creates financial risk when NorthWestern is short on energy and exposed to market prices. Adding flexible resources such as batteries and fast-ramping natural gas allows NorthWestern to quickly adjust resources according to market conditions and take advantage of the price spikes. Since NorthWestern is a participant in the W-EIM, simulated prices for select Montana W-EIM nodes were created using an historical basis between Mid-C and the W-EIM prices. The basis between Mid-C and each W-EIM was simulated individually based on the historical price spread.

Figure 8-6a. Monthly Forecasted Prices at Mid-C

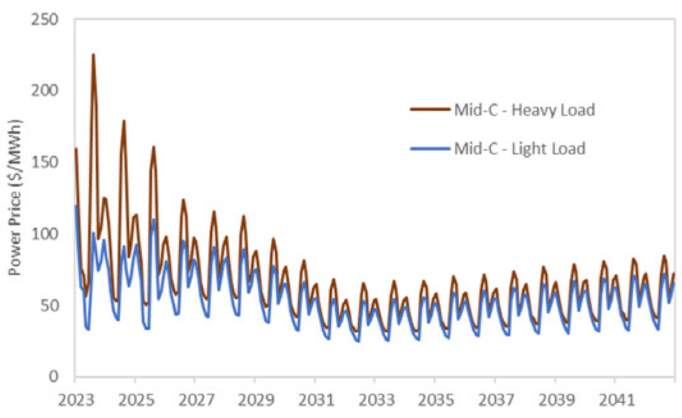
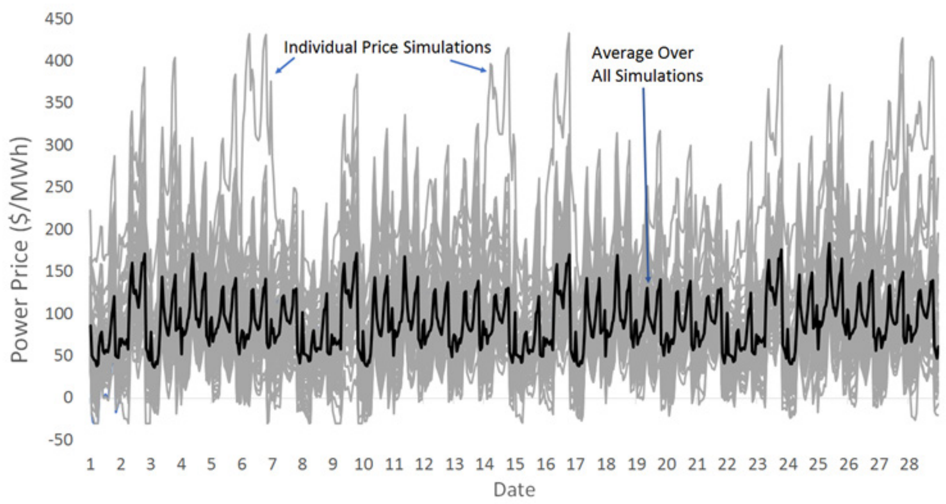
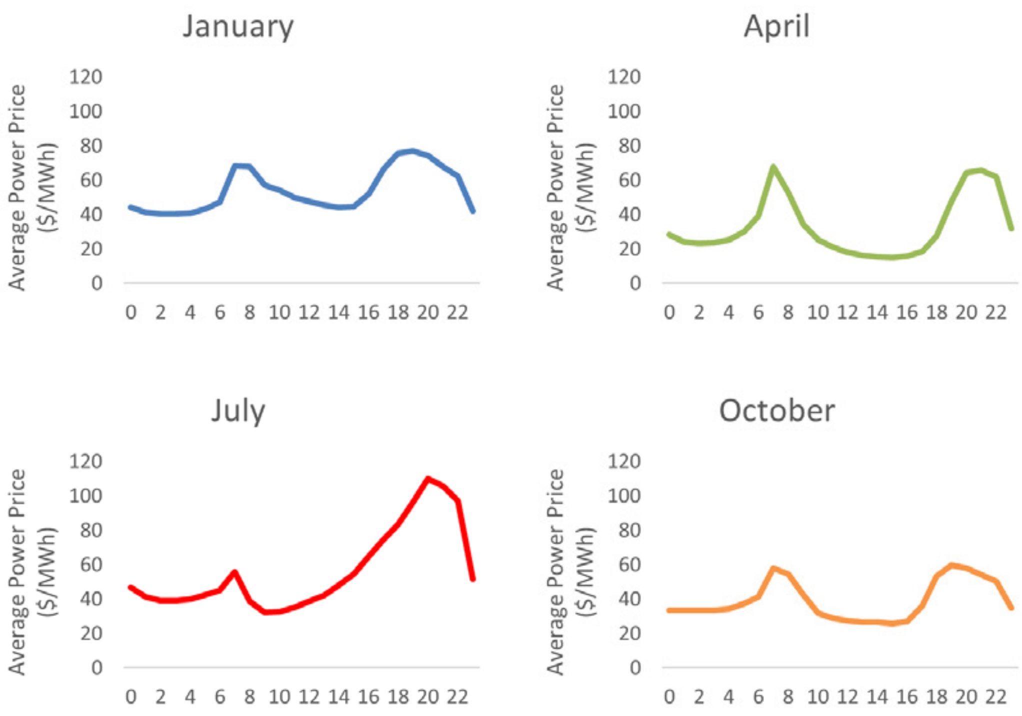


Figure 8-6b. One Hundred Price Simulations for February 2025 Showing the Range of Uncertainty and Hour to Hour Price Volatility



A key aspect of future power markets is that the influx of renewable energy is expected to increase the frequency of periods in which supply exceeds demand and power prices become negative. The pattern of renewable energy putting significant downward pressure on average prices has been seen in California as the rapid growth of solar energy has saturated the market with daytime energy and pushed the net peak (load minus renewable generation) into the evening after the sun sets. This phenomenon is not as apparent in the Mid-C market, though the Mid-C and California markets are influenced by each other. The combination of the reduction in average prices with the increase in price volatility represents a shift in the underlying fundamentals of power markets. This shift is driven by the replacement of dispatchable resources with intermittent resources. Figure 8-7 shows how the daily price shapes are expected to change over time during different seasons of the year in the year 2030 when solar and wind are expected to generate a quarter of the energy in the Pacific Northwest.

Figure 8-7. Daily Price Shape Projections by Month in 2030



8.4.4. Carbon Prices

The core capacity expansion runs did not include a cost of carbon applied to NorthWestern's resources. However, the effects of carbon pricing in California were included in the Mid-C price forecast. The modeling team investigated carbon price effects as a sensitivity case with a representation of a carbon cost equal to the California carbon prices applied to NorthWestern resources. Carbon was modeled deterministically and operates as a cost added to the dispatch of carbon resources, meaning a greenhouse gas emitting resource would only dispatch if the power price was higher than the variable cost of the unit plus the carbon cost. Carbon prices applied to NorthWestern resources were assumed to not affect Mid-C prices due to the small size of NorthWestern within the region.

8.5. Effective Load Carrying Capability for Wind, Solar and Storage

The WRAP provides a regional resource adequacy and compliance program which sets the planning reserve margins for member utilities and provides capacity accreditation for all resources in the region. All resources in NorthWestern's portfolio were accredited under WRAP including planned resources that have yet to be built.

WRAP determines capacity accreditation for resources with an effective load carrying capability (ELCC) analysis. The ELCC metric provides a capacity accreditation value for variable and energy limited resources such as wind, solar, and storage. ELCC is the standard method for the determination of accredited capacity value throughout most of the U.S. The process to calculate ELCC relies on multiple resource adequacy models that ultimately determine the resource adequacy benefit attributed to a test resource (wind, solar, or storage). Since WRAP is a regional program, the ELCC analysis includes all resources and loads within the WRAP. ELCC values of wind, solar, and storage in WRAP will be a function of the regional resource needs and the ability of Montana wind, solar, and storage to meet those needs. Prior to joining the WRAP, NorthWestern conducted ELCC analysis for wind, solar, and storage resources using NorthWestern's resources and load in the model. ELCC values based on a regional model will not necessarily align with ELCC values calculated with a NorthWestern model.

All wind, solar, and storage resources in NorthWestern's portfolio have been assigned an ELCC value. The most recent wind, solar, and storage resources in the model provide guidance on the capacity value of new wind, solar, and storage for WRAP (Table 8-4).

Table 8-4. WRAP and Historical ELCC Values for Wind, Solar, and Storage

	WRAP Calculations		NorthWestern Historical Values	
ELCC Source	Summer ELCC	Winter ELCC	Summer ELCC	Winter ELCC
Wind	13%	31%	13%	13%
Solar	30%	3%	30%	1%
Storage (4hr)	80%	80%	100%	100%

WRAP does not provide ELCC values for future, hypothetical wind, solar, or storage resources. For that reason, ELCCs for future wind, solar, and storage are used equal to the WRAP values in the table above. For eight hour or longer duration storage, a 100% ELCC is assumed.

8.6. Scenarios and Sensitivities

Through PowerSIMM modeling, NorthWestern evaluated NorthWestern's portfolio under various future scenarios. The set of future scenarios is meant to capture future paths that will greatly affect future procurement decisions. For this plan, NorthWestern focused on the future of Colstrip due to its importance in the NorthWestern supply portfolio. The following scenarios were included in the modeling. A set of core assumptions applies to all scenarios.

All scenarios below assume YCGS comes online in 2024, Apex Solar comes online in 2023, and MTSUN comes online in 2023. No QFs in the current queue were assumed to come online because NorthWestern is not able to accurately project which QFs will ultimately be constructed.

Table 8-5. Scenarios Modeled in the Planning Process

No.	Scenario	Description
1	Base Case	NorthWestern's current portfolio including the Colstrip 222 MW acquisition beginning Jan 1, 2026.
2	Colstrip Retirement in 2030	Colstrip 222 MW acquisition occurs in 2026 and then Colstrip retires in 2030. The model indicates replacement resources.
3	Colstrip Retirement in 2035	Colstrip 222 MW acquisition occurs in 2026 and then Colstrip retires in 2035. The model indicates replacement resources.
4	Colstrip Retirement in 2025 with renewable replacements	Colstrip retires in 2025. The model can only select wind, solar, and energy storage for future procurements. The scenario was provided by the Joint Environmental Group[36] in comments for ETAC.
5	Colstrip Retirement in 2035 with SMR replacement	Colstrip 222 MW acquisition occurs in 2026 and then Colstrip retires in 2035. A 320 MW SMR replaces Colstrip.

In addition to the above scenarios, NorthWestern modeled sensitivities to determine how the model inputs affect results. Sensitivities can be thought of as "what if" analysis. Results from sensitivity analysis allows planners to understand how the optimal resource mix changes with different assumptions for the future. Sensitivities were applied to all scenarios above.

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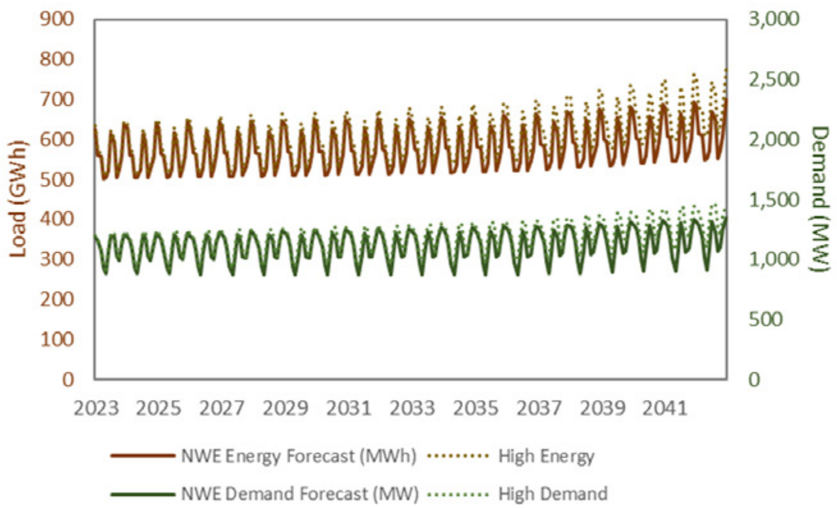
[36] The Joint Environmental Scenario was proposed in written comments submitted on May 9, 2022, after the April 20, 2022 ETAC meeting by Renewable Northwest, Montana Environmental Information Center, and the Sierra Club Montana Chapter. The comments requested NorthWestern to study the Colstrip retirement scenario where the replacement options consisted of solar, wind, storage (battery and pumped-hydro), and hybrid resources. NorthWestern ran the model with a 2025 retirement for Colstrip.

Table 8-6. Sensitivities Used in the Modeling Process

No.	Sensitivities	Description
1	High Load	NorthWestern's load grows at twice the expected rate
2	High Gas Prices	Natural gas prices are double the current forecast
3	High Gas and Power Prices	Power prices increase with natural gas prices
4	Carbon Cost	Carbon prices in California are assumed to be applied to NorthWestern's carbon-emitting resources

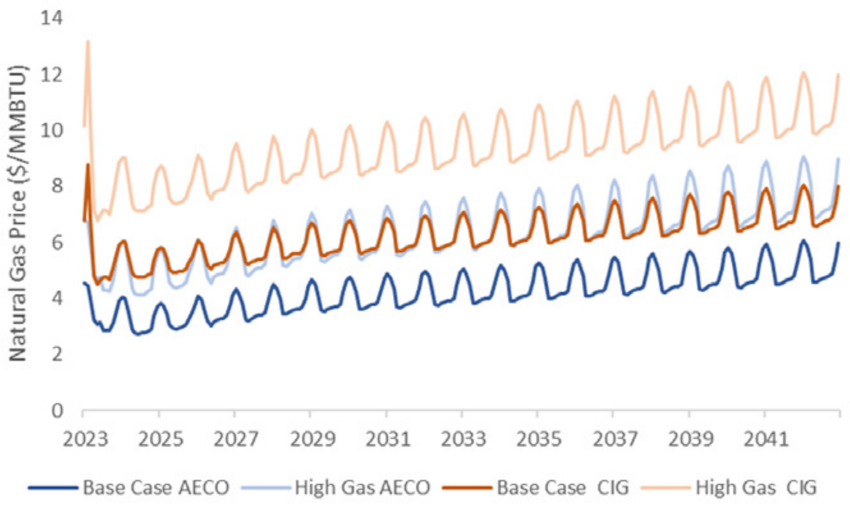
NorthWestern's load forecast and the high load sensitivity are shown together in Figure 8-8. Annual load growth in the Base Case is roughly 0.3% until 2035 when load growth becomes 0.88%. In the high load sensitivity, annual growth for load and demand doubles compared to the base case. The result is an additional 125 MW and 800,000 MWh of load in 2042 compared with the Base Case.

Figure 8-8. Load forecasts used in the High Load Sensitivity and the Base Case



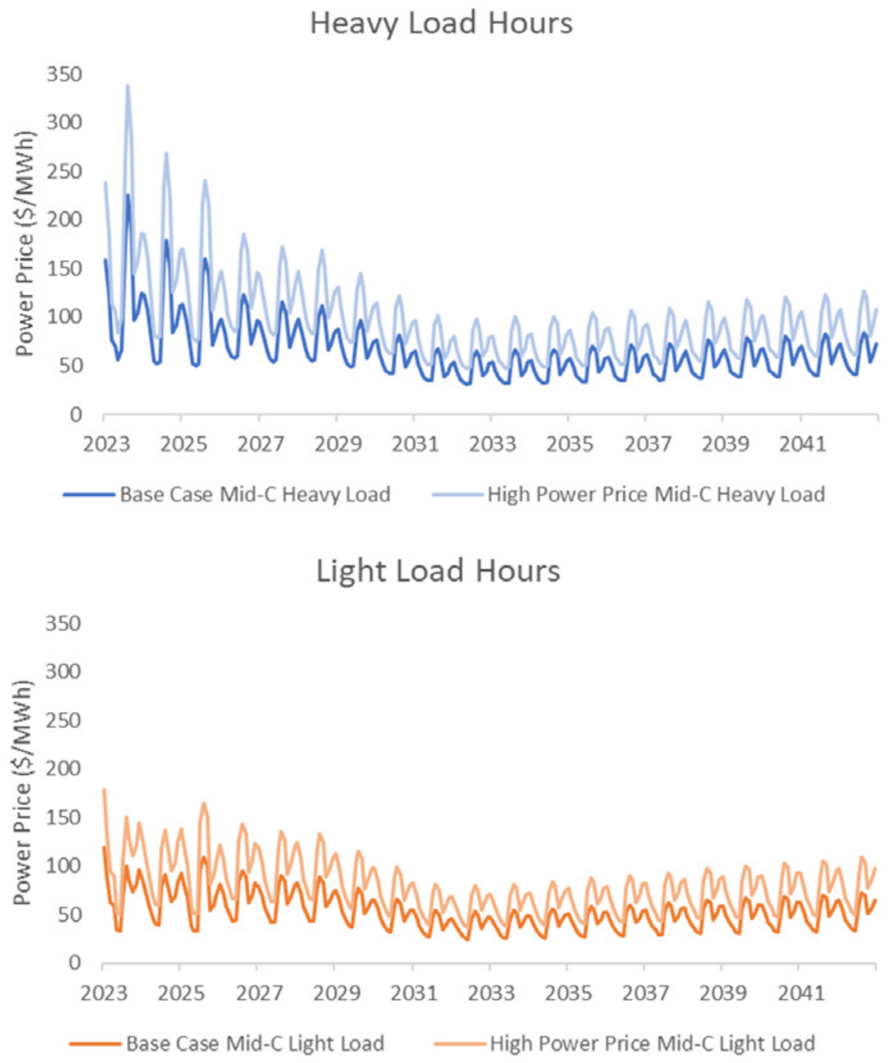
In the high gas price sensitivity, gas prices are assumed to double the prices used in the Base Case. In a high gas price future, natural gas generation will have lower capacity factors.

Figure 8-9. High Gas Price Forecast Compared to the Base Case Gas Prices



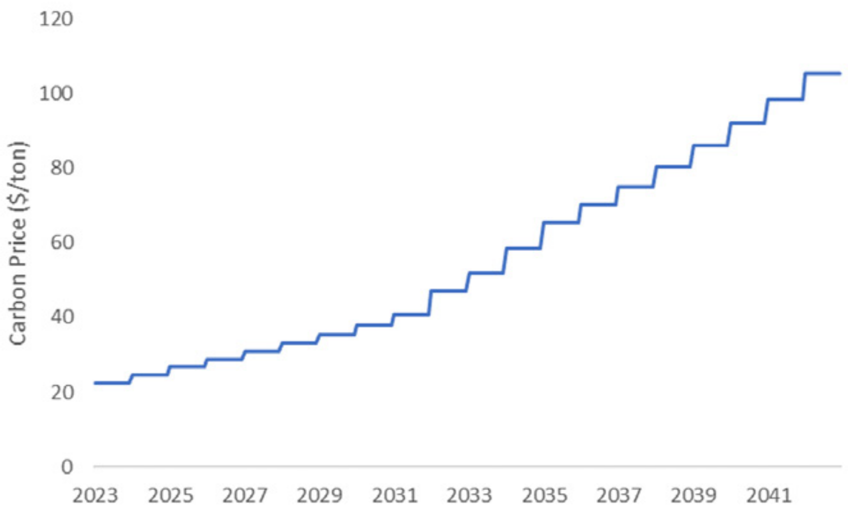
For the high gas and high power price sensitivity, the power price was adjusted upwards to match the implied heat rate of the Base Case. Natural gas generation capacity factors should resemble the Base Case capacity factors. The high power price future will provide more value for resources that do not run on natural gas.

Figure 8-10. High Power Price Forecast Compared to the Base Case Power Price Forecast



The carbon price sensitivity assumed that carbon prices in California are applied to NorthWestern resources. The Base Case price forecast for Mid-C includes effects from carbon pricing in California and Washington. Carbon prices applied to NorthWestern are assumed to have no effect on Mid-C prices due to the relatively small size of NorthWestern's system relative to the other utilities that trade power at Mid-C.

Figure 8-11. Carbon Price Used in Sensitivity Analysis



The sensitivities described above were applied to all scenarios listed in Table 8-5. Additional sensitivities were also run for the Base Case only. This includes:

1. Half of the QF queue is built in the next two years
2. The full QF queue is built in the next two years
3. NorthWestern does not acquire additional capacity of Colstrip
4. NorthWestern replaces Colstrip with an SMR in 2030 (instead of 2035)

QFs which interconnect through NorthWestern's system bring complexity and uncertainty to the Plan. For the core scenarios, none of the unbuilt QF Resources are assumed to come online. These include the resources listed in table 8-7. To implement the sensitivity assumption that half of the QF Resources would come online, NorthWestern reduced the QF capacity by resource type in the models. In the full QF sensitivity, all resources in the table below come online.

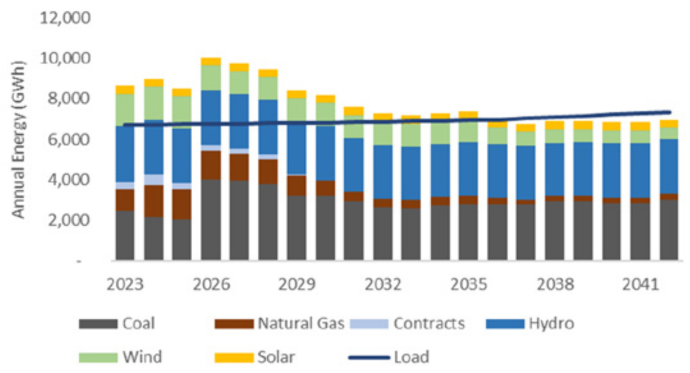
Table 8-7. Projects in the QF Queue for NorthWestern's Power Portfolio

Project Name	Technology	Interconnection Limit	Renewable Size	Storage Size	Planned Interconnection Year
Jawbone	Wind	80	80		2024
Pondera	Wind	20	20		2024
Teton	Wind	20	20		2024
Wheatland County	Wind	75	75		2024
CBC 1 - 4	Wind / Battery	315	320	100	2024
Trident	Solar / Battery	80	160	80	2025
Broadview	Solar / Battery	80	130	50	2023
Meadowlark	Solar / Battery	20	20	12	2023
Clenera – UDA	Solar	80	80		2023
CELP	Coal	40.5	0	0	2024
Total		**810.5**	**905**	**242**	

8.7. Capacity Planning Results

Figure 8-12 shows the annual energy generation versus load by year for NorthWestern's base case portfolio without future resource additions beyond the Colstrip acquisition. In the base case, NorthWestern's portfolio is long on energy through 2035.

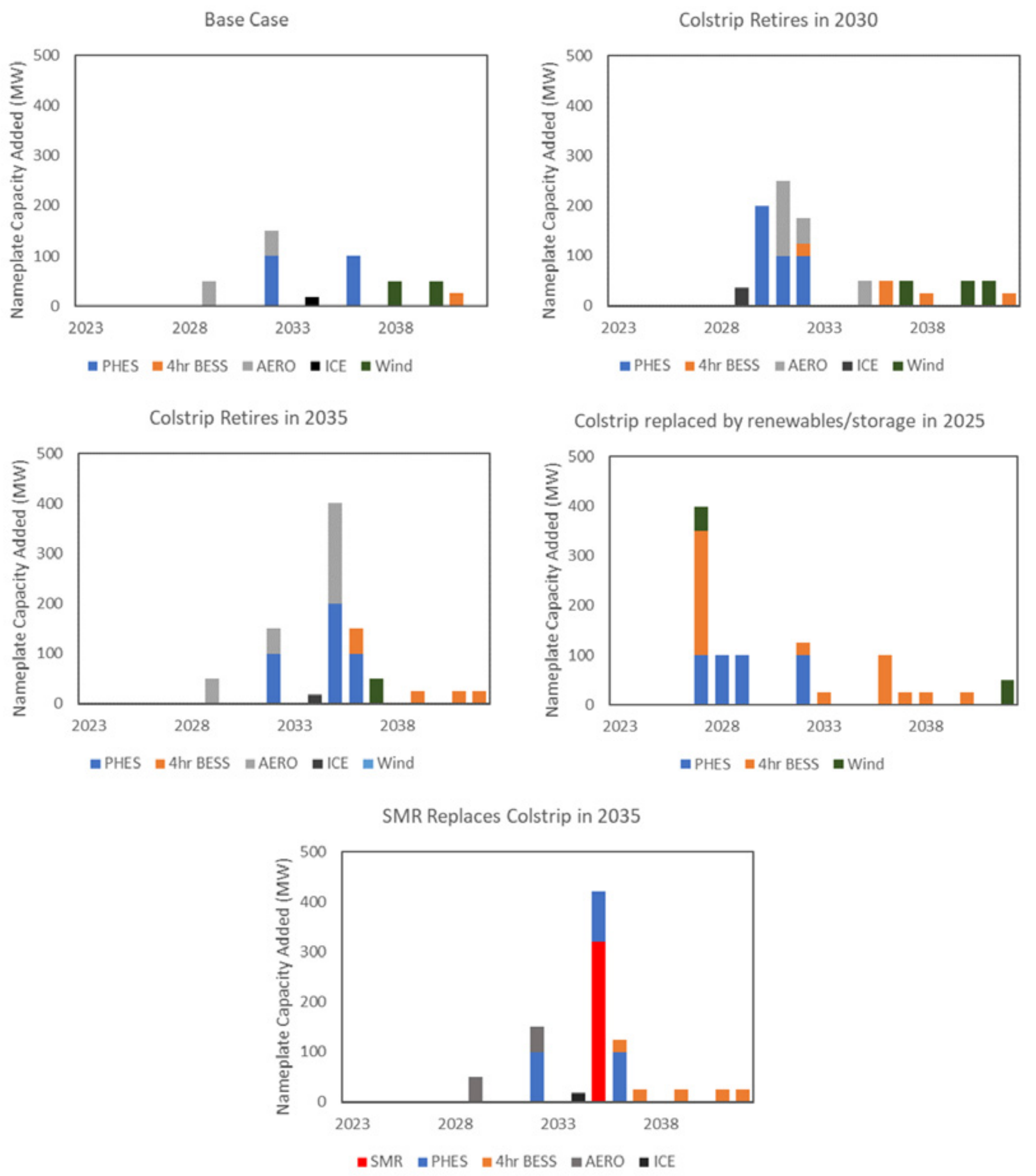
Figure 8-12. Base Case Energy Position without Additional Resources



In addition to the long energy position until 2035, Figure 6-5 in Chapter 6 shows that NorthWestern is long on capacity until 2029 for winter months and Figure 6-7 shows the summer capacity position is long until 2032 based on WRAP capacity accreditation and PRM requirements.

The following charts in figure 8-13 show the capacity expansion outputs for the Base Case scenario and early Colstrip retirement scenarios.

Figure 8-13. ARS Results for the Core Scenarios



The early retirement scenarios for Colstrip move up the resource build to replace the capacity deficit when Colstrip goes offline. After the 2026 Colstrip acquisition, Colstrip provides 444 MW of capacity which is generally replaced by flexible natural gas turbines and pumped-hydro storage. In scenarios 4 and 5, the replace option was constrained to understand the resource build-out if Colstrip retires and NorthWestern opts for a particular replacement option.

Scenario 4 assumes replacement capacity comes from renewables and storage where the model relies heavily on energy storage and some wind. Note that scenario 4 results in a portfolio consisting only of two natural gas resources after 2036, DGGS and YCGS.

In scenario 5 NorthWestern assumes an SMR replacement for Colstrip in 2035. The SMR size is 320 MW with a very high capacity factor.

A summary of capacity expansion results appears in Table 8-8. The summary includes all sensitivities and additional studies. The key takeaways from the results are:

1. Energy storage (pumped-hydro and battery storage) and flexible natural gas resources (combustion turbines and internal combustion engines) provide the optimal mix of supply to achieve resource adequacy.
2. Early Colstrip retirement scenarios increase overall cost due to the need to replace the lost capacity with new resources.
3. In the 2030s, NorthWestern's long energy position will decline, making wind power more valuable.

Table 8-8. Summary of ARS Nameplate Capacity Results for All Modeled Scenarios

		PHES	4hr BESS	8hr BESS	AERO	ICE	Wind	Solar	SMR
Core Assumptions	Base	200	25	0	100	18	100	0	0
	Colstrip ret 2030	400	125	0	250	36	150	0	0
	Colstrip ret 2035	400	125	0	300	18	50	0	0
	Renew Rep 2025	400	475	0	0	0	100	0	0
	SMR Rep 2035	300	125	0	100	18	0	0	320
High Load	Base	200	175	0	50	18	0	100	0
	Colstrip ret 2030	400	175	0	300	18	0	50	0
	Colstrip ret 2035	400	200	0	250	54	0	50	0
	Renew Rep 2025	400	700	100	0	0	0	0	0
	SMR Rep 2035	300	225	0	50	18	0	50	320
High Gas Prices	Base	200	25	0	100	18	100	0	0
	Colstrip ret 2030	400	125	0	250	36	150	0	0
	Colstrip ret 2035	400	175	0	250	0	100	0	0
	Renew Rep 2025	400	475	0	0	0	100	0	0
	SMR Rep 2035	300	125	0	100	18	0	0	320
High Gas and Power Prices	Base	200	25	0	100	18	100	0	0
	Colstrip ret 2030	400	125	0	250	36	150	0	0
	Colstrip ret 2035	400	175	0	250	0	100	0	0
	Renew Rep 2025	400	475	0	0	0	100	0	0
	SMR Rep 2035	300	125	0	100	18	0	0	320
Carbon Costs	Base	200	50	0	100	18	50	0	0
	Colstrip ret 2030	400	125	0	250	54	50	0	0
	Colstrip ret 2035	400	175	0	250	0	100	0	0
	Renew Rep 2025	400	475	0	0	0	100	0	0
	SMR Rep 2035	300	225	0	50	18	0	0	320
Additional Studies	Base half QFs	200	75	0	50	36	50	0	0
	Base Full QFs	200	50	0	0	0	0	0	0
	SMR Rep 2030	400	25	0	150	36	0	0	320
	No Colstrip Exp	400	50	0	100	36	50	0	0

8.8. Resource Adequacy

NorthWestern's participation in the WRAP shifts resource adequacy requirements from the local resources and load to the regional portfolio of resources and load. While a portfolio may not necessarily be adequate from a loss of load perspective in NorthWestern's BA, it may cover NorthWestern's share of the regional resource adequacy requirements in WRAP. For this reason, NorthWestern did not adjust the portfolios coming out of ARS based on resource adequacy results.

Traditionally, a portfolio must maintain an annual loss of load expectation (LOLE) of 0.1 day/year to be considered adequate. Building resources to remove all risk of loss of load would be overly costly. With the WRAP program, NorthWestern is part of a regional pool of resources contributing to resource adequacy more efficiently without the need to meet the LOLE of 0.1 days/year for every utility in the region as long as the region as a whole can meet the 0.1 days per year LOLE threshold.

8.9. Cost and Risk

Portfolio costs include capital costs to procure new resources, fixed costs for current and new resources, and variable costs to serve load on an hour-by-hour basis. The ARS output portfolios were analyzed in production cost models to determine the total portfolio costs.

One driver of supply costs is market interactions. All scenarios projected a long position in energy generation leading to more market sales than purchases. Figure 8-14 shows the annual market position for the scenarios with core assumptions. In all scenarios the market sales drop over time while the purchases increase. Volume 2 contains annual charts for all scenarios and sensitivities.

Figure 8-14. Market Sales and Purchase Costs for Core Scenarios

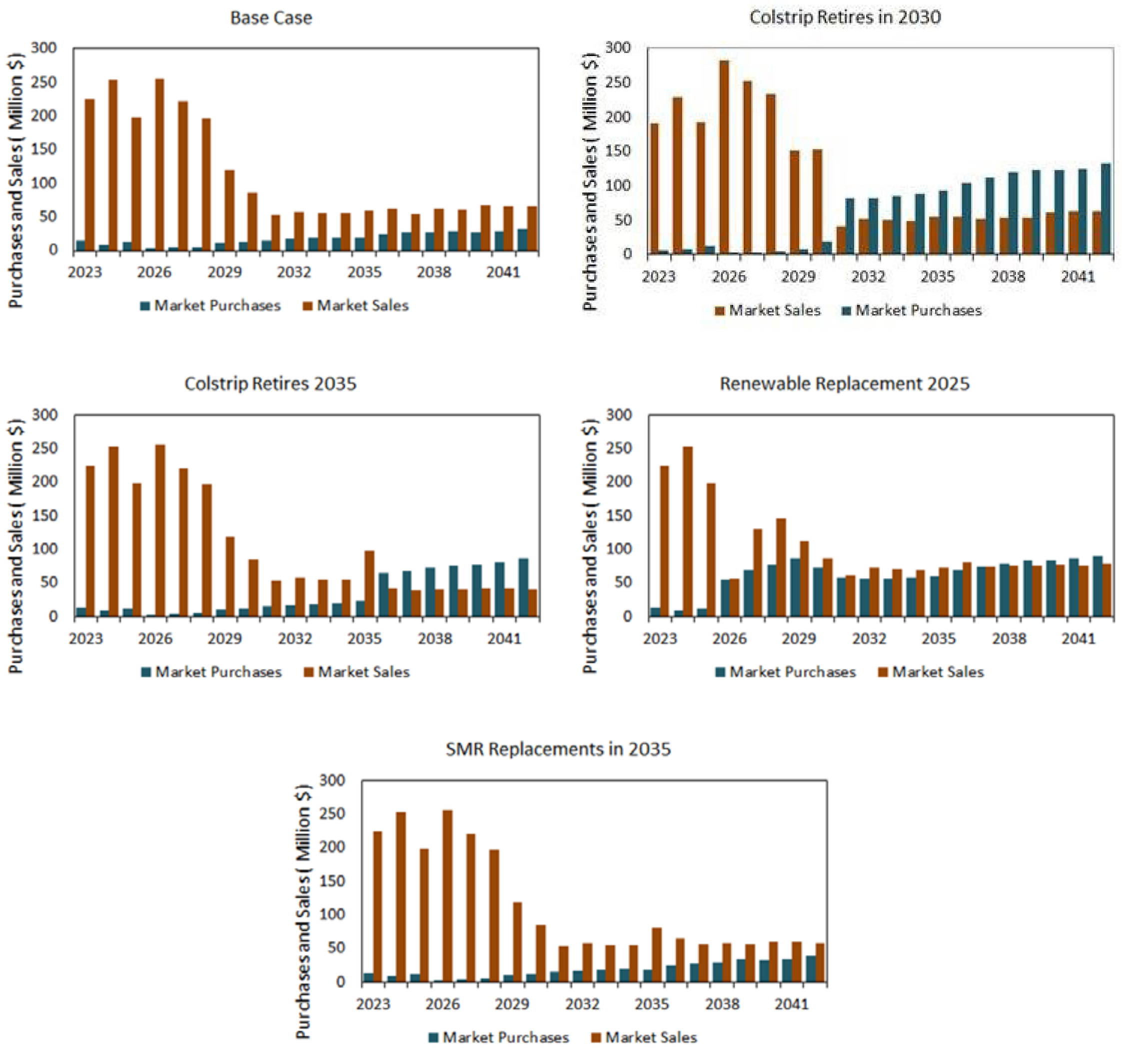


Table 8-9 shows total market sales by scenario. In the core scenarios market sales revenue is high due to the high market prices early in the model coupled with the Colstrip acquisition. As the modeled prices for power come down, the market sales drop.

Table 8-9. Market Sales ($ Billions) for 20 years

	Base Case	Colstrip Retires in 2030	Colstrip Retires in 2035	Renewable replacement 2025	SMR replacement 2035
Core Scenarios	$1.65	$1.52	$1.59	$1.35	$1.63

Figure 8-15 shows supply costs for the Base Case scenario over the next 20 years. The costs are separated into categories depicting the type of resource for the cost. Values in the figure include costs for revenue requirements, PPA costs, fuel costs, market purchases and market sales. Owned resources make up the largest cost category as expected, but contracted resources, which include QFs, make up a significant portion of total costs. Market sales subtract from the overall costs which is why the total is $4.5 billion when market sales are included in the calculations.

Figure 8-15. Total Supply Costs Separated by Cost Category

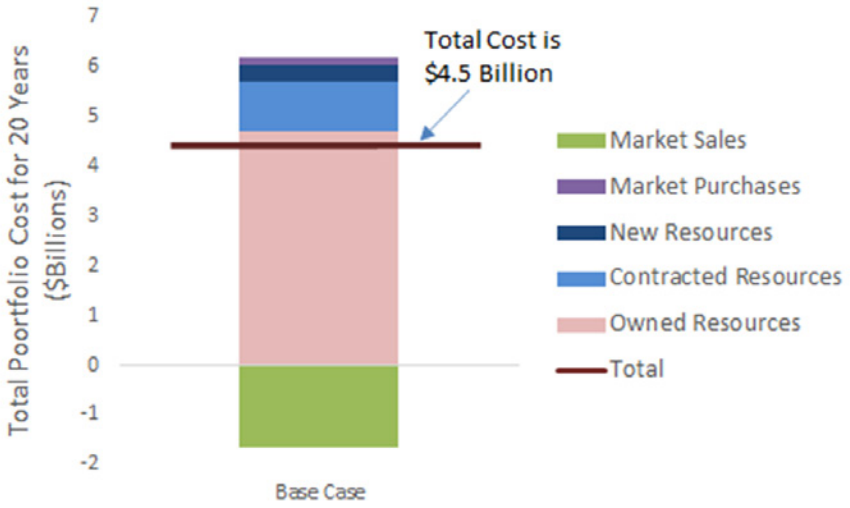


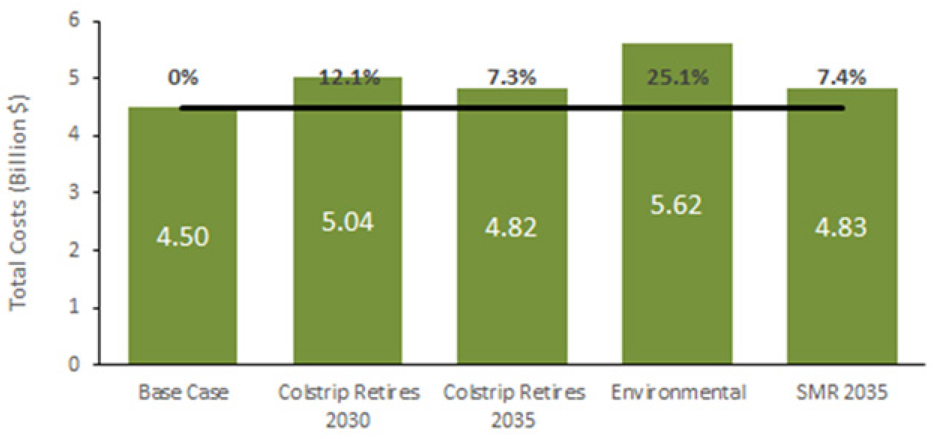
Table 8-10 shows the sub-hourly credits applied by resource type. Sub-hourly credits were estimated in a sub-hourly PowerSIMM model that dispatched resources to the hourly price at Mid-C and a real-time price at the NorthWestern W-EIM node. The model showed the extra value that a flexible resource can capture through the real-time market of the W-EIM.

Table 8-10. Sub-Hourly Credits for Flexible Candidate Resources

SH Credits ($/KW-yr)					
Year	4hr Battery	8hr Battery	PHES	CT	ICE
2025	$55	$66	$26	$39	$38
2026	$71	$83	$33	$34	$34
2027	$80	$92	$37	$33	$34
2028	$85	$100	$40	$34	$34
2029	$94	$110	$44	$35	$35
2030	$93	$109	$43	$34	$35
2031	$97	$114	$45	$34	$35
2032	$100	$116	$46	$36	$37
2033	$106	$123	$49	$40	$41
2034	$112	$130	$52	$42	$43
2035	$115	$134	$54	$44	$44
2036	$119	$138	$55	$48	$48
2037	$114	$134	$53	$51	$51
2038	$123	$145	$58	$55	$55
2039	$129	$152	$61	$59	$59
2040	$135	$157	$63	$62	$62
2041	$133	$157	$63	$64	$65
2042	$143	$167	$67	$71	$70

Supply costs for all scenarios can be compared by aggregating discounted costs over time to get the net present value of total costs. In the current plan NorthWestern estimates that achieving a resource adequate portfolio in both summer and winter months would result in a supply cost increase of roughly 4.3%[37] which translates to a 2.29% increase or a $2.36/month on a customer's monthly bill in 2027.[38] Figure 8-16 compares the total supply cost for the Base Case scenario and early retirement scenarios. The Base Case scenario had the lowest cost over the 20-year modeling time frame which is expected since it had the least number of constraints placed on the ARS model. The cost of procuring replacement capacity causes the early Colstrip retirement scenarios to be higher than the Base Case.

Figure 8-16. **Total Costs for Core Scenarios**



The sensitivity studies tested the core outputs to determine how the results change under the adjusted assumptions. Table 8-11 shows the total cost outputs for the five scenarios under the four different sensitivities.

Table 8-11. **Total cost from 2023 to 2042 in Billions of Dollars for All Scenarios and Sensitivities**

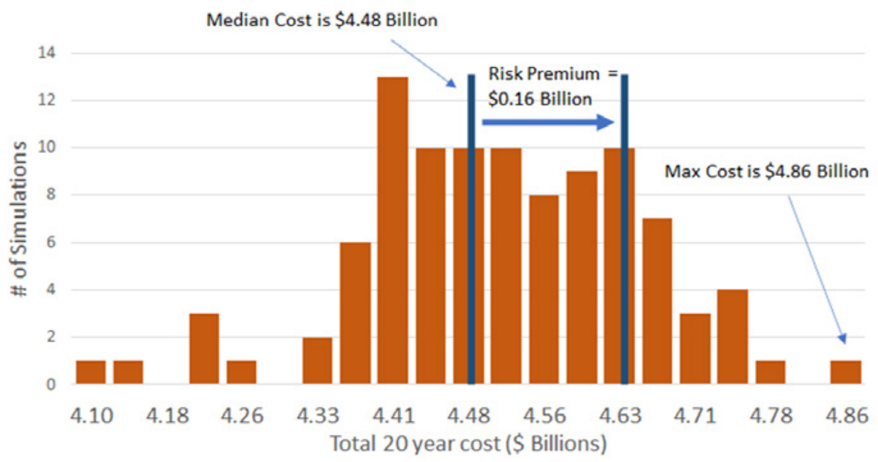
Sensitivity	Base Case	Colstrip Retire 2030	Colstrip Retire 2035	Environmental	SMR 2035
Core	4.50	4.95	4.82	5.86	4.82
High Load	4.88	5.24	5.11	6.04	5.10
Has Gas Price	4.83	5.23	5.08	6.10	5.06
High Gas and Power Price[39]	4.22	4.97	4.67	6.33	4.51
Carbon Costs	5.52	5.60	5.95	6.26	5.95

The outputs in Table 8-11 show the Base Case is the least cost option for the range of sensitivities tested. In the carbon price sensitivity, the differences are small because of the high carbon cost from Colstrip. In the high gas and power price sensitivity the market sales push the prices down as there was no constraint on the amount of sales from the portfolio.

Full details of all results are included in Volume 2 of the plan.

The total cost of a portfolio over 20 years is a function of many factors including market sales and purchases, fuel costs, power costs, load, and renewable generation. The core scenarios were modeled with 100 simulations to understand the total cost risk associated with each scenario. We quantify the risk with a "risk premium" calculation for each portfolio. Figure 8-17 shows the distribution of total costs for all 100 simulations for the Base Case along with the median cost ($4.48 billion) and max cost ($4.86 billion). Also shown in the figure is the risk premium which is the difference between the median value of the distribution and the average cost between the median and max value. In this case the average between the median and max value is $4.64 billion so the risk premium is $4.64 - $4.48 = $0.16 billion.

Figure 8-17. **Risk Premium Calculation of Base Case**



The risk premium values for all scenarios are shown in Table 8-12.

Table 8-12. **Risk Premium of All Scenarios**

	Base Case	Colstrip Retire 2030	Colstrip Retire 2035	Environmental	SMR 2035
Risk Premium (Billion)	$0.167	$0.183	$0.178	$0.193	$0.167

The Base Case has the lowest risk premium along with the SMR replacement scenario because these scenarios are insulated against gas price fluctuations. The remaining scenarios include resources that are more exposed to fuel price risk which leads to higher risk premium values.

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[37] Because the base case model assumes no new resources can be built prior to 2027 (with the exception of YCGS) and the portfolio is resource adequate in 2026 with the additional share of Colstrip, no additional resources will be needed to achieve resource adequacy. However, some additional cost may be incurred with the possibility of acquiring additional resources to achieve resource adequacy prior to 2026 such as through short-term contracts. Other factors can influence the Supply portfolio cost including QF additions, Opportunity Resource acquisitions, etc.

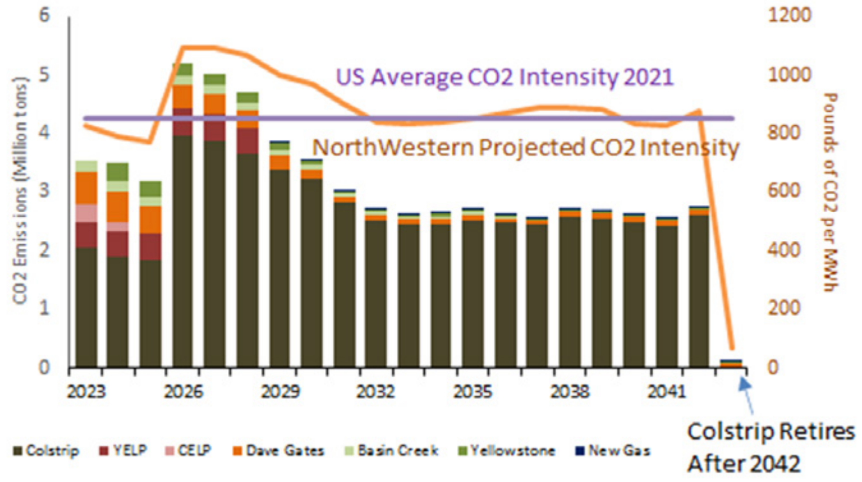
[38] Based on average customer consumption of 750 kWh.

[39] Total costs assume unconstrained market sales and no transmission constraints.

8.10. Carbon Emissions

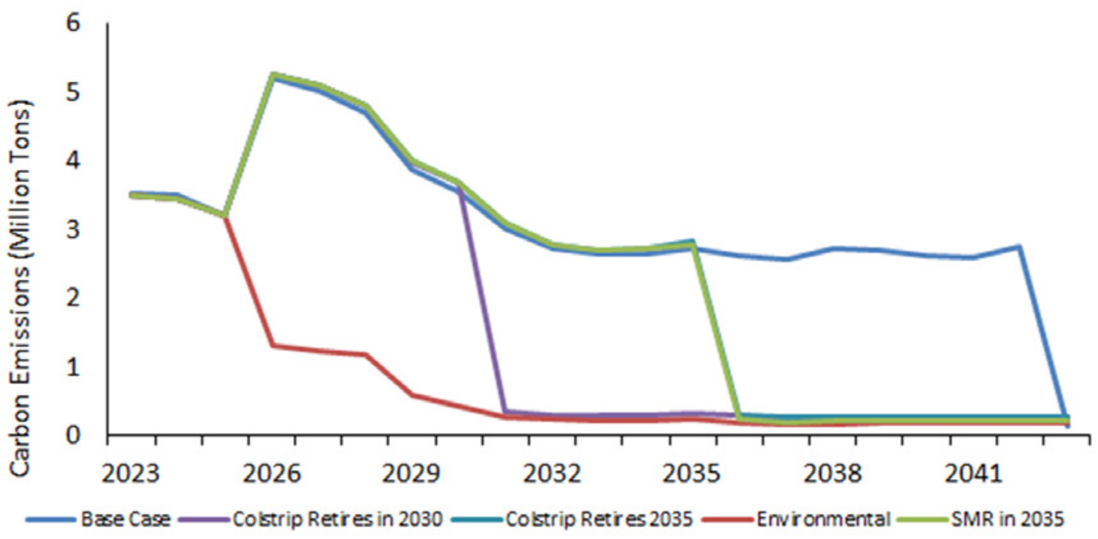
In the Base Case production cost outputs, NorthWestern's portfolio emits roughly 3.5 million tons of carbon annually in 2023 which increases to 5 million tons in 2026, Figure 8-18. The carbon intensity of the portfolio is roughly 850 pounds (lbs.) per MWh which is roughly in line with the current U.S. average carbon intensity of 853 lbs. per MWh[40]. After the Colstrip retirement in 2042 the carbon emissions drop.

Figure 8-18. Carbon Emissions for the Base Case Scenario



The largest overall emitter of carbon in the portfolio is Colstrip since it is the largest thermal resource and provides more energy than all other thermal resources. CELP and YELP have larger emissions than Colstrip on a per MWh basis, but do not generate as much energy. Carbon emissions increase in 2026 from the Colstrip acquisition. Figure 8-19 shows total emissions by year and by scenario.

Figure 8-19. Total Annual Carbon Emissions by Scenario



The majority of NorthWestern load is served from wind, solar, and hydro generation. Over the next 20 years, the ratio of load served from renewables is expected to remain above 50%. Figure 8-20 shows the energy mix for the Base Case. Nationally, wind and solar make up 30% of electricity generation while 59% of generation comes from coal and natural gas.[41]

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[40] Values taken from eia.gov for national electricity generation (4,007,135,000 MWh) in 2021 and carbon emissions (1,551,179,000 metric tons). The ratio of these values results in 853 lbs. of carbon per MWh of electricity nationwide.

[41] US Energy Information Administration (EIA); U.S. Energy-Related Carbon Dioxide Emissions, 2020; https://www.eia.gov/environment/emissions/carbon/#_ftn2

Figure 8-20. Base Scenario Energy Mix 2023 to 2042

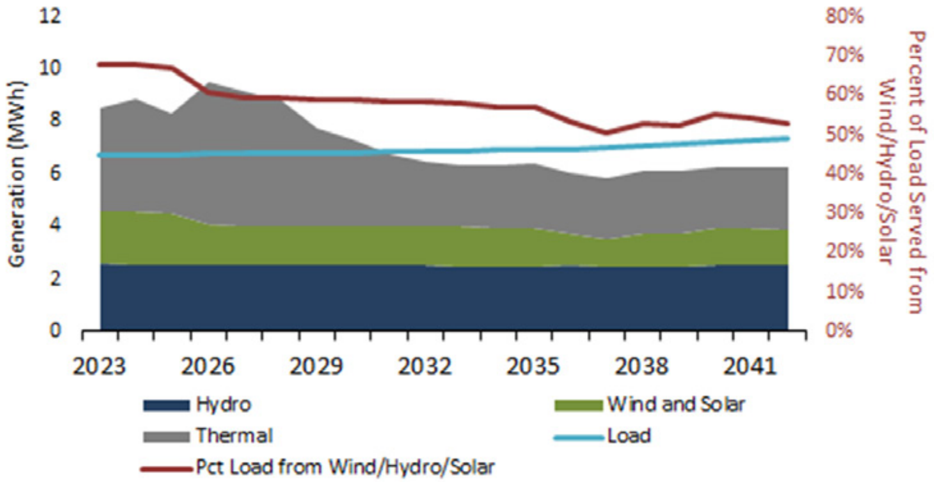


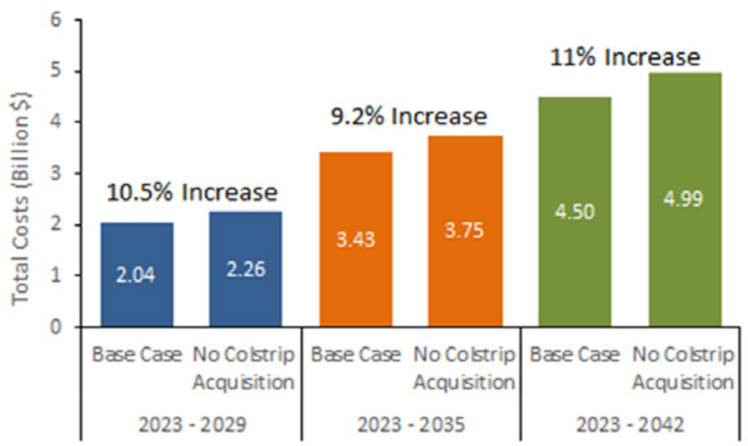
Figure 8-20 shows a decline of generation from thermal resources. The model used price forecasts showing a decline in the implied market heat rates which leads to lower dispatch of thermal resources. Additionally, thermal retirements include CELP in 2024, YELP in 2028, and Basin Creek in 2036.

Note the natural gas resources in the model are projected to run at low capacity factors, especially after 2029 due to the declining power prices. Colstrip has a drop in capacity factor in 2024 and 2025 as a result of scheduled maintenance in the model. After 2026, Colstrip operates economically without a must-run requirement.

8.11. Additional Studies

NorthWestern completed studies to compare the cost of serving load with and without the Colstrip 222 MW acquisition. Figure 8-21 shows the total net present value of costs for 2023 – 2029, 2023 – 2035, and 2023 – 2045 for NorthWestern's portfolio with and without the Colstrip acquisition. The Colstrip acquisition has cost benefits that increase over time and total nearly $500 million by 2042, the last year Colstrip is expected to generate power.

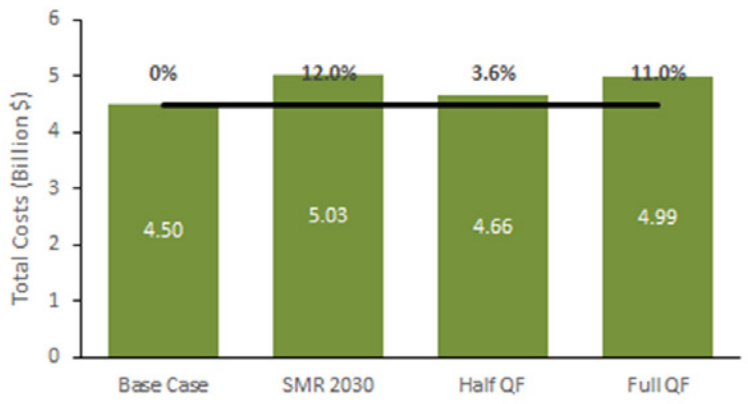
Figure 8-21. Total Cost of Base Case, No Colstrip Acquisition Scenarios Over Different Time Periods



The cause of the cost increase without the Colstrip acquisition comes from the requirement to build new resources in lieu of the Colstrip acquisition. The Colstrip acquisition comes at no increase in the rate base for NorthWestern due to the zero upfront acquisition cost. The resource procurement costs in the No Colstrip Acquisition scenario are higher than the added operational costs for the Colstrip acquisition.

The results of other additional studies are shown in Figure 8-22. They include the SMR replacement of Colstrip in 2030 (five years sooner than the core study), half QF build, and full QF build. The results show the level of cost increase over the Base Case if Colstrip is replaced early by an SMR or if more QFs are built.

Figure 8-22. Total Cost Results - Additional Studies



9. Emerging Technologies

9.1. Electric Vehicles[42]

NorthWestern is monitoring electric vehicle (EV) adoption to better understand and plan for the impacts of EVs and electric vehicle supply equipment (EVSE). EVs are expected to gain market share during NorthWestern's resource planning period. While EV adoption in Montana has lagged other parts of the country, technological and infrastructure improvements are anticipated to improve their viability as an option to internal combustion engine vehicles.

After defining an EV growth model and a loading model for EV charging, NorthWestern summarizes the findings in terms of anticipated load during afternoon peak hours due to private charging of electric vehicles for both managed and unmanaged charging behavior (Table 9-1).

Table 9-1. Summary of Potential Load During Afternoon Peak Hours Due to At-Home Charging of Electric Vehicles for Both Managed and Unmanaged Charging Behavior

Estimated Afternoon Peak Loads Due to At-Home EV Charging[43]			
	2022	2027	2032
Number of EVs in NWE's MT Service Territory NWE mid-adoption forecast	**2,171**	**9,351**	**21,553**
Unmanaged At-Home L2 Charging Load	3.8 MW	16.4 MW	37.7 MW
Managed At-Home L2 Charging Load	NA	2.3 MW	5.4 MW
Number of EVs in Montana AECOM mid-adoption forecast[44]	**4,720**	**19,470**	**40,300**
Unmanaged At-Home L2 Charging Load	8.3 MW	34.1 MW	70.5 MW
Managed At-Home L2 Charging Load	NA	4.9 MW	10.1 MW

NorthWestern also analyzed the demands associated with the buildout of a statewide direct current fast charging (DCFC) network. For the near-term and likely scenario, NorthWestern utilized the Montana Electric Vehicle Infrastructure Deployment Plan developed by MDEQ. In total, this buildout would represent an increase in DCFC load of about 45 MW (Table 9-2).

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[42] For a more detailed analysis of how these numbers were derived see Volume 2 Chapter 10.

[43] Load estimates are based on the EV forecast model specified in the table and on Pacific Northwest National Laboratory's, Electric Vehicles at Scale – Phase 1: High EV Adoption Impacts on the Western U.S. Power Grid research paper. PNNL's "at-home" charging scenarios are utilized which assume 91% of private EV charging is done at home.

[44] AECOM is a consulting firm that provided EV forecasts to MDEQ.

Table 9-2. Summary of the Estimated Current, Planned, and Potential Dcfc Load in NWE's Service Territory

Estimated Current, Planned, and Potential DCFC Load[45]			
	2022	2027	2032
DCFC Load	~ 3 MW	12.6 MW	45 MW

9.2. Advanced Metering Infrastructure (AMI)

NorthWestern plans to install 590,000 new electric meters and gas modules between 2021-2024. In 2021, about 69% percent of all U.S. electric meter installations were smart meters.[46] Smart metering provides more data on grid operations, which will allow opportunities for new customer programs and technology that will help balance the energy grid with renewable resources. Today, this technology allows two-way communication between NorthWestern and its meters on customers' homes and businesses. In most cases, the system will notify NorthWestern of an outage. It helps crews restore service faster, provides current energy use information for customers' questions about bills, use, and opportunities about energy savings, and even identifies system voltage information before problems cause outages. The latest information may be found at Montana Meter Upgrade (northwesternenergy.com).

9.3. Nuclear Resource Options

SMRs are becoming a realistic energy producing technology capable of providing reliable, safe, and carbon-free power. There are numerous SMR designs utilizing different technologies, with the most advanced and safest being those that fall under Generation III and IV designs. Since the publication of NorthWestern's 2019 Plan, the development of Generation III and IV SMRs has advanced quickly, with numerous countries deploying their own designs. In the U.S., designs including X-Energy, TerraPower, and NuScale have been leading the way for SMR development. See Volume 2 for additional discussion on SMRs.

9.4. Hydrogen

Hydrogen resources are not modeled in this Plan; however, as an emerging technology, it is important to mention its future potential. Clean hydrogen is expected to have a greater contribution in meeting the total energy demand by 2050.

According to the Office of Energy Efficiency and Renewable Energy, while hydrogen technology will likely have a place in energy production in the future, it is important to be mindful that this type of resource requires a large amount of energy to operate. It is expected that hydrogen facilities may play a role in shifting energy produced by intermittent resources, like wind farms.[47] NorthWestern will continue to monitor hydrogen's development and feasibility as a future resource.

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[45] 2022 load estimates are based on 2014-2021 monthly usage data for NWE-served DCFCs. 2027 load estimates are based on the Montana Department of Environmental Quality's planned DCFC installations in NWE's service territory as part of their Montana Electric Vehicle Infrastructure Deployment Plan to satisfy the National Electric Vehicle Infrastructure program requirements. 2032 estimates are based on an exponential curve fit of the 2014-2021 historical usage data.

[46] EIA Frequently Asked Questions (FAQS): How many smart meters are installed in the United States, and who has them? https://www.eia.gov/tools/faqs

[47] See The Office of Energy Efficiency & Renewable Energy's Hydrogen Production: Electrolysis https://www.energy.gov/eere/fuelcells/hydrogen-production-electrolysis.

10. Action Plan

NorthWestern is short of meeting the PRM. NorthWestern must continue to monitor a number of significant variables that will affect its capacity position. NorthWestern will:

1. **Participate in the ongoing development of the WRAP**

The WRAP is a regional reliability and compliance program that leverages resource diversity and coordination to ensure generating capacity is available to serve regional demands and peak load events[48]. The program standardizes metrics for assessing resource adequacy and benefits reliability in the region through collaboration and enhanced operating efficiencies, such as sharing of pooled resources. The WRAP provides guidance on the capacity accreditation of renewables and energy storage while also establishing a target capacity for resource adequacy. Capacity accreditations in the WRAP are based on the regional supply mix and regional resource needs. Participating members of WRAP agree to share resources across the region when supply conditions tighten. NorthWestern and its customers will benefit from the program by improvements to the capacity position, which reduces the risk of blackouts. As a founding member of the WRAP, NorthWestern remains an active participant in future WRAP development while influencing the vision of resource adequacy in the region.

2. **Proceed towards commercial operation of YCGS**

NorthWestern considers the completion of YCGS a critical part of the strategy to reach an adequate portfolio. As such, NorthWestern will continue working to maintain the progress of completing the YCGS construction by its expected in-service date in 2024. The added capacity from YCGS will improve NorthWestern's position in the W-EIM and WRAP, while also providing more flexibility to better integrate wind and solar resources.

3. **Continue to monitor the need for an RFP, evaluate Opportunity Resources, and track QF development while working towards a resource adequate portfolio**

NorthWestern may initiate an RFP to increase the amount of supply for NorthWestern customers. A decision on a possible RFP will depend on the QF queue, potential Opportunity Resources, and future developments with Colstrip. NorthWestern will continue to evaluate Opportunity Resources as they become available.

4. **Evaluate the potential early closure of Colstrip**

As the future of Colstrip becomes more clear, NorthWestern may need to replace the lost capacity from its largest single resource. Given the large impact a Colstrip retirement would have on NorthWestern customers, NorthWestern will closely monitor developments regarding Colstrip.

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[48] More details on WRAP: WPP (westernpowerpool.org) https://www.westernpowerpool.org/about/programs/western-resource-adequacy-program

5. Execute the DSM RFP

NorthWestern issued a RFP to conduct a feasibility study for DSM. The analysis will take place in 2023 and provide information regarding opportunities to assist customers with energy efficiency programs that meet cost-effectiveness requirements. The feasibility study is a critical step in expanding NorthWestern's program offerings and updating the measures NorthWestern implements in future programs.

6. Monitor the acceleration of "electrification"

The adoption of electric vehicles and electric equipment for space and water heating will increase demand for electricity and alter the daily use patterns for electricity. NorthWestern will continue to monitor and forecast the changing electric demand for planning.

7. Evaluate the development of new technologies

New technologies for energy supply such as hydrogen or SMRs will likely play a strong role in the future electric grid. NorthWestern follows the research and market developments for innovative and new technologies. Future technologies are included in planning studies as they develop and become likely future resources for NorthWestern.

8. Study the most effective transmission expansion opportunities

Transmission expansion requirements will be evaluated as new resources come online. NorthWestern will study the need to expand transmission to accommodate additional supply and improve reliability. Given the challenges of congestion on the transmission system, NorthWestern continues to analyze the most pressing upgrades needed for relieving congestion.

NorthWestern will continue its environmental stewardship efforts and plan for its Net Zero commitment by 2050 with no new carbon resources added after 2035.

11. Appendix A – Frequently Asked Questions

Q. Why isn't "electrification" or the idea that an increasing use of electricity in everything from heating to EVs reflected in the projected load growth for NorthWestern?

A. Given how early we are in the growth curve of EV adoption and the potential range of NorthWestern's ability to manage the peak load of EVs on the system, more certainty is needed before adopting this particular growth in the forecast. In addition, the penetration of additional electrification in things like water and home heating remains uncertain. When a clearer picture emerges NorthWestern will consider that in load-growth models.

Q. I see the terms capacity and energy being used a lot in the Plan. What is the difference between energy and capacity?

A. Electricity is measured in both capacity and energy. Capacity is measured in watts, kilowatts (kW), and megawatts (MW). In this plan we most often use megawatts (MW) when talking about capacity. Energy is measured in kilowatt-hours (kWh) and megawatt-hours (MWh). In this plan, we most often use the term megawatt-hours (MWh). The terms capacity and energy are used to describe generation characteristics of resources, and are also used to describe customers' loads. Understanding the difference between energy and capacity is critical to understanding the resource needs of our customers and the generation capabilities of different types of generation.

The term "capacity" is used in many different ways, but the two primary definitions used when describing a generation facility are 1.) Nameplate capacity, which is the maximum output (MW) a generation facility can physically produce, and 2.) Peaking capacity, which is the reliable level of output (MW) that a generation facility is able to produce during a peak load event. Most generators do not operate at their full nameplate capacity except in limited circumstances.

For example, for a small hydro facility with a nameplate capacity of 19 MW, the facility may be capable of producing at the full 19 MW for every hour in a day during the month of May when runoff is high. However, on a cold day in January, when loads are at their highest (peaking) and stream flows are lower, the facility may only be capable of producing 9 MW during the highest load hours of the day. If so, it would be appropriate to say that that facility has a peaking capacity of 9 MW, or that it has a peak capability of 47% (peaking capacity divided by nameplate, or 9 MW / 19 MW).

The term "energy" refers to the amount of electricity a generation facility produces over a specific period of time, normally over an hour, month or year. Energy production is generally less than maximum capability for most of the year.

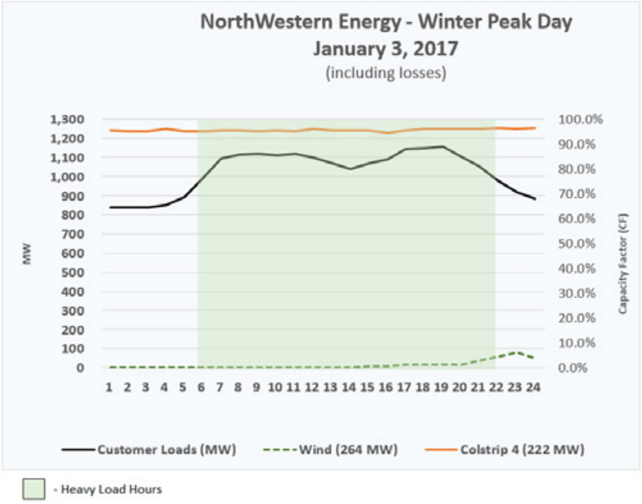
For example, using the same 19 MW hydro facility producing at the full 19 MW per hour for every hour during a day in May when runoff is high, it would be appropriate to say the facility produced 456 MWh on that day (19 MW x 24 hours). On a day in January, when stream flows are lower, the facility might produce an average of 8 MW for every hour in a day. If so, it would be appropriate to say that the facility produced 192 MWh on that day (8 MW x 24 hours).

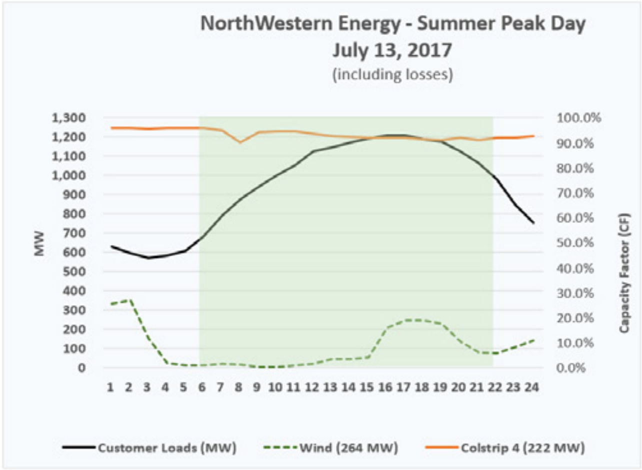
Q. Wind and solar appear to be low-cost resources. Why does your model select natural gas generation over wind and solar?

A. Wind and solar are capable of providing low-cost energy but are generally not available to provide capacity when customers need it most, like after sunset on the coldest winter days in December and January.

Wind is typically only producing about five percent of its maximum capability on those days (5% of nameplate capacity). Theoretically, this means NorthWestern would need to build a wind facility that is about twenty times larger than a natural gas facility to obtain about the same amount of capacity needed to serve customers during peak loads. However, the capacity provided by a wind facility is not reliable enough to plan on being available during peak loads and in periods when twenty times larger isn't enough to provide reliable service.

To illustrate this point, the graphs below show NorthWestern's peak load days for 2017. The black line represents customer load (shown as megawatts on the left hand scale), while the dashed green line shows wind production (from the 364 MW of wind available at the time as percentage of its nameplate capacity on the right hand scale. The orange line represents Colstrip 4 production, also shown as a percentage of its nameplate capacity on the right hand scale.

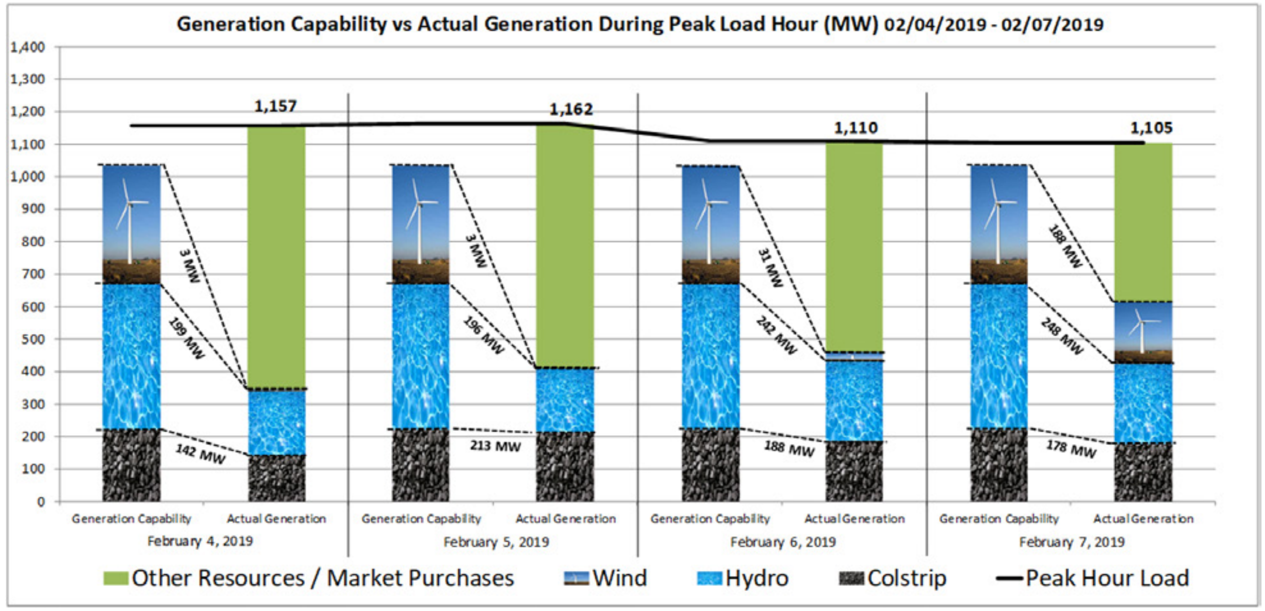




As illustrated in the graphs, wind contributed very little of its maximum generation capability (especially on the critical winter peak day), while Colstrip 4 generated at 90 to 95 percent of its maximum capability. During peak load periods, customers need resources that NorthWestern can call upon as needed, 24 hours a day, 7 days a week. One way to increase the reliability of wind to provide capacity during peak load periods is to add battery storage. However, adding the battery storage needed makes the wind/battery combination much more expensive.

NorthWestern didn't include solar on the above graph because we did not have very much solar operating on our system. However, we have modeled solar production and have found that when compared to wind solar has a higher capacity contribution during the summer, but provides no capacity contribution during the winter when peak load hours occur after sunset.

Another example comes from the cold spell the week of February 4th, 2019. The figure below shows that wind generation contributed very little to NorthWestern's peak load capacity need during that cold weather period. During the peak load hours on February 4th and 5th, wind was generating at 1% or less of its total nameplate capacity (3.2 MW and 2.5 MW respectively out of a nameplate capacity of 364 MW).



It's important to note that wind generation can vary significantly from hour-to-hour or even within the hour. NorthWestern cannot control the output from wind generation like we can with other resources. Because of this, NorthWestern must set aside (reserve) the generation capability of other resources on our system to balance variations in wind. NorthWestern's flexible resources such as coal, gas, and hydro are used to offset variations in wind and load.

Q. You say that you are going to provide for customers' needs using competitive solicitations. What kind of resources do you expect to be bid into a competitive solicitation?

A. NorthWestern conducted an RFP in 2020 and received proposals from a number of different resource technologies, including:

- Wind plus battery
- Solar plus battery
- Wind and solar
- Wind and solar plus battery
- Battery storage technologies
- Pumped hydroelectric storage
- Existing hydroelectric resources
- Compressed air energy storage plus battery
- Reciprocating engine technologies
- Combustion turbine technologies
- Combustion turbine plus battery
- DSM

We anticipate receiving proposals from a similar, if not greater, range of technologies during any future competitive solicitation process. The resources chosen from the process will be based on costs and performance.

Q. The resource plan has a lot of abbreviations and terms that I am unfamiliar with. Do you have a way for me to translate?

A. Yes. At the back of the Plan we have included a list of abbreviations and a glossary defining the terms used in the Plan.

Q. If reducing exposure to the market is one of the goals of acquiring resources, why did NorthWestern join the Western Energy Imbalance Market (W-EIM)?

A. NorthWestern's customers already have exposure to increased market prices for energy and capacity because we are short capacity needed during peak load times. Before, NorthWestern transacted bilaterally with other companies, meaning that it made purchase or sale arrangements directly with those companies. The W-EIM changes how some transactions are conducted, but it doesn't increase the market exposure that NorthWestern's customers already have. NorthWestern maintains full control of its bid amounts in the W-EIM.

Q. You discuss the possibility of NorthWestern eventually being part of a full organized market such as a Regional Transmission Organization (RTO), and that this market would likely have a specific capacity reserve requirement. Could NorthWestern avoid the need to procure capacity by choosing not to join an RTO?

A. No. NorthWestern already has the need for capacity. The rules of an RTO would specify how to calculate this need, and how different types of resources are counted toward meeting this need, but joining an RTO would not fundamentally change the need to have capacity in place.

Q. What about a Green Tariff?

A. NorthWestern is working with a number of stakeholders regarding a Green Tariff, but plans are not far enough along to evaluate the effects and thus warrant inclusion in this Supply Plan. From a supply planning perspective, adding a resource under a Green Tariff would be similar to adding a solar, wind, or other renewable resource.

Q. Does the Plan select resources that NorthWestern will build?

A. First, it is important to understand that the Plan itself does not select a resource. It only provides a snapshot in time of the cost estimates for any particular resource. Actual resources are added to the portfolio through a competitive solicitation process which evaluates all resources bid in at the costs the bidder provides, selection of an opportunity resource evaluated in a similar manner, or through the QF process. Bidders, where appropriate, will factor effects of the IRA into their bids or project offers at the time NorthWestern is seeking a new resource. This misconception of the Plan's role in resource acquisition is commonly held.

Q. How does the Inflation Reduction Act (IRA) factor into this Plan?

A. Modeling in this Plan assumed the tax credits from the IRA applied to wind, solar, and energy storage. The IRA extended the Production Tax Credit (PTC) until 2032 for wind. Solar and nuclear now can receive the PTC. Energy storage receives the Investment Tax Credit (ITC) without the requirement to charge from a renewable resource. The PowerSIMM model inputs were updated to include the PTC for wind, solar, and nuclear and the ITC for energy storage.

12. Appendix B - Glossary

A	
Ancillary Services	Those services that are necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the transmission system in accordance with good utility practice. These services include, among others, Regulation and Frequency Response, Reactive Power, Contingency Reserve, incremental and decremental capacity.
Automatic Generation Control (AGC)	Software and equipment that automatically adjusts generation in a Balancing Authority Area from a central location to maintain the Balancing Authority's interchange schedule.
Available Transmission Capacity	(ATC) Available transmission capacity after considering firm commitments.
Average Annual Energy	The total amount of energy, measured in kWh or MWh, delivered over a period of one year divided by 8,760 hours per year.
Avoided Costs	Incremental cost for energy generated or acquired from another source.
B	
Balancing Authority	The responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports interconnection frequency in real time.
Balancing Authority Area	The collection of generation, transmission, distribution infrastructure, and load-resource balance within the metered boundaries of the Balancing Authority.
Baseload	The minimum amount of electric power delivered or required over a given period at a constant rate.
C	
Capacity	(Nameplate capacity) The maximum power output potential a machine or system can produce or carry under specified conditions generally expressed in kW or MW; (current capacity) instantaneous measurement of power delivery; (capacity resource) expression of capability to serve load.
Capacity Factor	The ratio of actual output to potential output over a period of time. Normally calculated by actual output in MWh divided by the product of nameplate capacity times 8,760 hours.
CapEx	Capital expenditure reflecting the cost of a resource, a project, or the expense to repair an asset.
Choice Customer	(NorthWestern) A NorthWestern electric service customer with an average monthly demand greater than or equal to 5,000 kW who chooses to buy power from a third party but uses NorthWestern transmission distribution, and other ancillary services (defined in § 69-8-201, MCA).
Contingency Reserves	As defined by NERC Standard BAL-002-WECC-2a, capacity held for deployment in the event of a contingency such as a generator or transmission trip. Contingency Reserve is comprised of Spinning and Non-spinning Reserves.
Cooling Degree Day	(CDD) A measurement used to indicate a building's cooling (air conditioning) energy consumption, defined relative to an outside (base) temperature, below which the building needs no cooling.
CPS1	(NERC Control Performance Standard 1) A regulating standard for calculating the frequency error for a balancing authority.

CPS2	(NERC Control Performance Standard 2) A regulating standard for balancing authorities intended to minimize excessive power flows due to corrections to CPS1 scores.
D	
DEC	Capacity to decrease generation output on short notice (sub-hourly, typically within the 10 to 15 minute timeframe). Also called decremental capacity.
Demand	The rate of electrical use during a period of time.
Demand Response	Programs used by utilities as resource options for balancing supply and demand with methods such as time-based rates, peak pricing rates, and direct load control.
Demand Side Management	The potential for adjustment of consumer demand for energy through various methods such as financial incentives and behavioral change.
Deterministic	Process or model in which the output is fully determined by inputs, thus containing no variability or risk.
Dispatchability	The ability of a generating resource to deliver or adjust its output on demand.
Distributed Energy Resources	Small generation resources, energy storage, energy efficiency, and demand response resources on the distribution system, substation, or behind a customer meter that store or produce electricity and are not otherwise included in the formal NERC definition of the Bulk Electric System or at levels below 100kV.
E	
EIM	Energy Imbalance Market, a real-time power trading market system that dispatches the lowest-cost energy to serve real-time customer demand. Entities that join the EIM remain responsible for their reliability standards as well as the requirement to enter with sufficient capacity.
ETAC	Electric Technical Advisory Committee is a diverse group of business, government, and energy professionals that advise NorthWestern on its energy supply planning.
F	
Flexible Capacity Resource	A resource that can be dispatched (operated) relatively quickly to provide ancillary services such as regulation, spinning reserve, non-spinning reserve, INC, or DEC. This could include storage and demand response as well as generation.
Flexible Resource	A generating plant that has the capability to handle fast start-up, bi-directional ramping, and shut-down demands.
G	
Geothermal Energy	Heat energy generated and stored in the Earth, which can potentially be converted to create steam to generate electricity.
H	
Heating Degree Day	(HDD) A measurement used to indicate a building's heating energy consumption, defined relative to an outside (base) temperature, above which the building needs no heating.
Heat Rate	The amount of thermal energy (Btus) required by a generating unit to produce 1 kWh of electrical energy, expressed in this Plan as the higher heating value heat rate.
Heavy Load Hours	(On-Peak Hours) The hours designated as traditionally having higher energy use; defined as hour ending 7 through hour ending 22 from Monday – Saturday.
Higher Heating Value	(Heat Rate) A specific measure of the heat of combustion, the total energy released as heat, which is determined by bringing all products of combustion back to pre-combustion temperature and condensing any vapor produced.
Hydros	The system comprised of 11 hydroelectric dams and 1 storage dam purchased by NorthWestern in 2014 from PPL Montana.
I	
INC	Capacity to increase generation output on short notice (sub-hourly, typically within the 10 to 15 minute timeframe). Also called incremental capacity.
Independent System Operator	An independent federally regulated entity established to coordinate regional transmission in a non-discriminatory manner and to ensure the safety and reliability of the electric system. ISOs typically include day-ahead and real-time markets for energy and ancillary services, with some including capacity markets.
Intercontinental Exchange	A trading platform that helps to define markets through an electronic exchange including energy commodities and other products.
Implied (Market) Heat Rate	A calculation of the day-ahead electric price divided by the day-ahead natural gas price. (Note that only a generation source with an operating heat rate efficiency below the calculated value can make money in the market.)
Inadvertent Generation	An unintended power exchange that was either not agreed upon or in an amount different from the amount scheduled, and is usually attributed to the variable energy resources.
Integration	(Resource use) The process of adding new generation resources and rebalancing the operations of existing resources in a portfolio to continue to meet load and other balancing authority requirements, including regulation reserves, imbalance service, and scheduling.
Interconnected	(Transmission Grid use) The condition of being electrically connected and in synchronous operation with the electric transmission system operated by a BA.
Intermittent	(Resource use) Not continuously available, random, or varying in output.
Inverter	An electronic device that converts direct current (DC) to alternating current (AC), i.e., solar PV generation to grid-compatible power.
J	
Jointly-Owned Coal Units	(JOU) A coal facility owned by multiple parties. These parties may be in different states and markets.
K	
L	
Light Load Hours	(Off-Peak Hours) The periods of the week designated as traditionally having lower system demand; hours not included in the definition of Heavy Load Hours.
Load	The net use of electric power from the transmission and distribution system for customers or devices.
Load Following	The use of on-line generation, storage, or load equipment to track the intra- and inter-hour changes in retail loads, similar to regulation, but over longer periods of time.
Load Shifting	Moving the time period of a portion of electricity demand from higher demand hours to lower demand hours.
Long-term resource	A supply resource that provides energy or capacity beginning four or more years into the future for an indefinite timeframe.

Loss of Load Expectation	(as defined by NERC) The expected number of days per year for which available generating capacity is insufficient to serve the daily peak demand (load). The LOLE is usually measured in days/year or hours/year. The convention is that when given in days/year, it represents a comparison between daily peak values and available generation. When given in hours/year, it represents a comparison of hourly load to available generation. LOLE is sometimes referred to as loss of load probability (LOLP). Also see LOLP.
Loss of Load Probability	(as defined by NERC) The proportion (probability) of days per year, hours per year, or events per season that available generating capacity/energy is insufficient to serve the daily peak or hourly demand. This analysis is generally performed for several years into the future and the typical standard metric is the loss of load probability of one day in ten years or 0.1 day/year. Also see LOLE. The NWPCC uses a metric, which establishes a minimum threshold LOLP standard of 5% for the Columbia River Basin (Region).
M	
Marginal Unit of Generation	The next higher cost of generating an additional MWh (energy) compared to the current cost of energy supply.
Minimum Down Time	(Generator use) A constraint on the least amount of time that a generating unit must be off after shutdown, typically due to necessary maintenance.
Minimum Up Time	(Generator use) A constraint on the least amount of time that a generating unit must be on once it starts, typically to minimize thermal stresses in the equipment.
Must-take	(Resource use) A plant that requires, by physical design or contractual agreement, that the owner or purchasing customer accept all power production as it is generated.
N	
Nameplate Capacity	The maximum rated generating output of a facility under specific conditions defined by the manufacturer.
NERC	North American Electric Reliability Corporation is a nonprofit corporation formed by the electric utility industry to promote the reliability and adequacy of bulk power transmission in the electric utility systems of North America.
Net Energy Metering	(NEM) Measuring the difference between the electricity distributed to and the electricity generated by a customer-generator that is fed back to the distribution system during the applicable billing period.
Net Present Value	The present value of future cash flows at a determined rate of return, used to discount future values back to today's dollars for a cost comparison of multiple projects, for example, alternative energy supply portfolios.
New Source Review	A CAA permitting program that requires industrial facilities to install modern pollution control equipment when they are built or when making a change that increases emissions significantly (as defined by EPA).
Nodal Prices	Prices for a commodity such as electricity and natural gas determined by location or supply (interconnect) points and conditions of supply and demand associated with that location.
Non-Spinning Reserves	Also known as "Operating Reserve – Supplemental." Reserves that are not online but are capable of coming online to serve demand within 10 minutes or interruptible loads that can be removed from the system within a similar timeframe.

Northwest Power Pool	A voluntary organization of utilities in the Northwestern U.S., British Columbia, and Alberta Canada focusing on reaching maximum benefits of coordinated operations of its members.
NREL SAM	National Renewable Energy Laboratory's system advisor model for systems-based analysis of solar technology improvement.
NREL Wind Toolkit	A national dataset of meteorological conditions and turbine power for over 126,000 sites across the U.S. provided by the National Renewable Energy Laboratory.
O	
Off-Peak Hours	Those hours defined by NAESB business practices, contracts, agreements, or guides as periods of lower electric demand and also may be those hours not included in On-Peak Hours (as defined in the QF-1 Tariff).
On-Peak Hours	Those hours defined by NAESB business practices, contracts, agreements, or guides as periods of higher electric demand and also may be the Heavy Load hours for the months of January, February, July, August, and December (as defined in the QF-1 Tariff).
Open Access	Federal Energy Regulatory Commission (FERC) Order 890: provides for non-discriminatory access to jurisdictional transmission systems to all eligible customers. NorthWestern has an Open Access Transmission Tariff.
Opportunity Resource	Those generation resources, either existing or new-build, which remain unknown as to their availability until an opportunity to purchase arises. Opportunity resources cannot be known or modeled in a resource planning process, but will be evaluated in a manner consistent with portfolio evaluation methodology in the 2023 Plan.
Optimization	Process of determining the lowest NPV utilization of resources to reliably meet energy, capacity, and ancillary needs.
Organization	An independent federally regulated entity established to coordinate interstate transmission facilities in a non-discriminatory manner and to ensure the safety and reliability of the electric system.
P	
P5	The 5th percentile of a sample is the value below which 5% of all values within that sample occur.
P95	The 95th percentile of a sample is the value below which 95% of all values within that sample occur.
Parasitic Load	The power consumed by a generating device or system for its own operation and/or when not generating, such as transformer losses in a solar PV system at night.
Peak Demand	The highest hourly net energy consumption for load.
Peak Shaving	Process of reducing the amount of energy purchased from a utility company during peak demand hours.
Performance Ratio	(Solar PV system) Ratio between actual annual production of AC energy and the theoretical annual production of energy.
Photovoltaic	An electricity generation system that converts sunlight (photons) into electric current (voltage) within a semiconductor panel.
Point of Interconnection (POI)	A location where two or more networks connect with one and other.
Portfolio	A specified mix of actual resources or selection by software, of various combinations of resources used to meet electric load demand.
Power Purchase Agreement	(PPA) A contract between the utility and generation facility owner that defines the terms of the purchase and sale of energy production.

Price-Taker	Company or resource that is not significant enough to influence the price of a good or service.
Pumped Hydro Energy Storage	A type of hydroelectric energy storage used by electric power systems for load balancing. The method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation.
Q	
Qualifying Facility	A small-scale renewable power producer that meets the capacity, fuel source, and operational criteria set forth by PURPA, including all pertinent requirements of Code of Federal Regulations Title 18 Conservation of Power and Water Resources and state law corollaries.
QF-1 Tariff	A MPSC approved electric tariff schedule that specifies rates and conditions for contracted renewable generation (Qualifying Facilities or QFs) power purchase terms between the utility (NorthWestern Energy) and the QF owner.
R	
Ramp Rate	Speed at which a generator can increase or decrease generation, typically measured in units of MW/minute during the ramp period.
Regional Haze Rule	(CO2 Emissions use) EPA CPP methodology for reducing CO2 emissions that uses goals specifying the ratio of pounds of CO2 emissions to the net energy produced, measured in units of (lbs. CO2/net MWh).
Rate-based	(CO2 Emissions use) EPA CPP methodology for reducing CO2 emissions that uses goals specifying the ratio of pounds of CO2 emissions to the net energy produced, measured in units of (lbs. CO2/net MWh).
Rate-based	(Resource use) A utility-owned generation resource in which the costs to purchase or build the resource are paid by the utility's customers through billed electric rates.
Real-time	The balancing and marketing of electric energy in the present-time as opposed to any future time. Also referred to as 24 hours a day, seven days a week.
Regression model	A technique to analyze a dependent variable's reaction to changes in other independent (explanatory) variables.
Regulation	An ancillary service consisting of reserves that are responsive to automatic generation control and are sufficient to provide normal regulating margin.
Reliability	Adequacy and security of the transmission system to operate properly under stressed conditions.
Reliability-Based Control	Refers to NERC Standard BAL-001-2, Real Power Balancing Control Performance. Among other things, the Standard requires a Balancing Authority to operate such that its Area Control Error does not exceed defined limits for more than 30 consecutive clock minutes. The Standard becomes effective July 1, 2016.
Renewable	A type of energy, or resource that generates the energy, that is produced from essentially sustainable fuel, such as falling water, wind, geothermal, or solar radiation.
Renewable Energy Credit	One megawatt-hour of renewable energy generation from an eligible renewable resource (defined by § 69-3-2003, MCA).
Reserve margin	Excess generating capacity above expected peak demand normally used in recovering from contingencies (unexpected events) within the BA.

Ride-through capacity	Ride-through capacity is defined as capacity that is available through an event like a cold snap or heatwave that could require multiple days of reliable generation. It is an important consideration when planning for peak load. The duration of such events is considered in the Loss of Load Probability (LOLP) analysis and influences the selection of supply resources.
Run-of-the-river	A hydroelectric dam that passes its inflow (through generating units and/or spill) due to limited reservoir storage potential.
S	
Short-term resource	A supply resource that provides energy or capacity up to four years in the future.
Solar PV	(see Photovoltaic) An electricity generating resource that uses sunlight as fuel to create an electric charge in semiconductor panels.
Spinning Reserves	On-line generation that is synchronized and ready to serve additional demand within ten minutes and can sustain that change in output for a minimum of sixty minutes, and can meet other WECC requirements.
Stochastic	A process in which there is inherent randomness; where the same inputs will produce a distribution of outcomes through iterative sampling of variables.
Sub-bituminous	An intermediate coal with properties between lignite and bituminous coal.
T	
Tier II	QF power purchase agreements that stemmed from MPSC Docket Nos. D97.7.90 and D2001.1.5, Order Nos. 5986w and 6353c.
Time of Use	A variable rate structure that charges customers a rate dependent on the time of day and season the energy is used.
Total Transmission Capacity	Total designed and approved transmission capacity of a transmission path (TTC).
Transmission Constraint	A condition where the electric transmission system is not able to transmit power to the location of demand, due to congestion at one or more points of the transmission network.
Turbine	A rotary mechanical device that extracts energy from a fluid (i.e. water) or the wind and converts it into work, such as turning a rotor.
U	
Utility System	The interconnected grid within the BA area consisting of generation, transmission, and distribution equipment.
V	
Variable Energy Resource	A renewable energy source that is non-dispatchable either due to its fluctuating nature or must-take contract requirements.
Volatility	The degree of variation of a market price over a period of time. High volatility indicates large price swings (either positive or negative) while low volatility indicates more stable market conditions.
W	
Waste Coal	A usable material byproduct of a previous coal processing operation.
Waste Coke	(Petroleum coke) A solid by-product of oil refineries that can be used as a fuel.
Weighted Average Cost of Capital	The rate that a company is expected to pay on average to all its security holders to finance assets. It is used to discount all costs back to present value in order to compare portfolio cash flows in the future. At the time of this Plan, NorthWestern used a WACC of 6.92%.

13. Appendix C – Abbreviations

#	
2023 Plan	2023 Electricity Supply Resource Procurement Plan
A	
AECO	Alberta Energy Company
Aion	Aion Energy LLC
AMI	Advanced Metering Infrastructure
aMW	Average megawatts, a unit of energy
ARM	Administrative Rules of Montana
Ascend	Ascend Analytics, LLC
ATC	Around-the-clock
ATC	Available Transfer Capability, a measure of remaining power transmission capability over and above already committed use (MW)
B	
BA	Balancing Authority
BESS	Battery Energy Storage System
BPA	Bonneville Power Administration
Btu/kWh	British thermal unit per kilowatt-hour, typical unit for heat rate
C	
CAA	Clean Air Act
CAISO	California Independent System Operator
CCCT	Combined cycle combustion turbine
CDD	Cooling Degree Days
CELP	Colstrip Energy Limited Partnership
CIG	Colorado Interstate Gas
CO	Carbon monoxide
CO2	Carbon dioxide
CPP	Clean Air Act Section 111(d) or Clean Power Plan
CREP	Community Renewable Energy Project
CT	Combustion turbine
D	
DER	Distributed energy resource
DEQ	Department of Environmental Quality
DGGS	Dave Gates Generating Station
DR	Demand response
DSM	Demand-side management
E	
E3	Energy and Environmental Economics, Inc.
EIA	U.S. Energy Information Administration
EIM	Energy Imbalance Market
ELCC	Effective Load-Carrying Capability
EPA	U.S. Environmental Protection Agency
ETAC	Electric Technical Advisory Committee

F	
FERC	Federal Energy Regulatory Commission
FIP	Federal Implementation Plan
Frame CT	Frame Simple Cycle Combustion Turbine
G	
GHG	Greenhouse gases
GW	Gigawatt, a unit of power (1,000,000,000 Watts)
GWh	Gigawatt-hour, a unit of energy (1,000 MWh)
H	
HDD	Heating Degree Days
HVAC	Heating, ventilating and air conditioning
Hydros	NorthWestern's hydroelectric generation facilities acquired in 2014
I	
IEEE	Institute of Electrical and Electronics Engineers
ICE	Intercontinental Exchange
IRP	Integrated Resource Plan
K	
kV	Kilovolt, a unit of voltage (1,000 Volts)
kW	Kilowatt, a unit of power (1,000 Watts)
kWh	Kilowatt-hour, a unit of energy
L	
LEDs	Light-emitting diodes
Li-Ion	Lithium-Ion
LOL	Loss of load
LOLD	Loss of load days
LOLE	Loss of load expectation
LOLH	Loss of load hours
LOLP	Loss of load probability
M	
MATL	Montana Alberta Tie Line
MCA	Montana Code Annotated
MDEQ	Montana Department of Environmental Quality
Mid-C	Mid-Columbia River electric trading hub
MMBtu	Million British thermal units, a unit of energy
MMcfd	Million cubic feet per day, a unit of volumetric flow rate
MPSC	Montana Public Service Commission
MW	Megawatt, a unit of power (1,000,000 Watts)
MWh	Megawatt hour, a unit of energy (1,000 kWh)
N	
NAAQS	National Ambient Air Quality Standards
NAESB	North American Energy Standards Board
NEEA	Northwest Energy Efficiency Alliance
NERC	North American Electric Reliability Corporation
NPV	Net present value
NREL	National Renewable Energy Laboratory

NWE	NorthWestern Energy
NWPCC	Northwest Power and Conservation Council
NWPP	Northwest Power Pool
O	
O&M	Operation & maintenance
OASIS	Open Access Same-Time Information System
P	
Plan	2023 Electricity Supply Resource Procurement Plan
PPA	Power purchase agreement
PRM	Planning Reserve Margin
PSC	Public Service Commission
PURPA	Public Utility Regulatory Policies Act
PV	Photovoltaic
Q	
QF	Qualifying Facility, as defined by PURPA
R	
RAS	Remedial action scheme
RBC	Reliability-Based Control
RFP	Request for Proposal
RICE	Reciprocating internal combustion engine
RTO	Regional transmission organization
S	
SCCT	Simple cycle combustion turbine
SIP	State Implementation Plan
SMR	Small Modular Reactor
SOGF	South of Great Falls Cut Plane
SPP	Southwest Power Pool
T	
TRC	Total resource cost
TTC	Total transfer capability, a measure of power transmission (MW)
U	
USB	Universal System Benefits
V	
VER	Variable Energy Resource
VOM	Variable operating and maintenance costs
W	
WACC	Weighted average cost of capital
WAPA	Western Area Power Administration
WECC	Western Electricity Coordinating Council
W-EIM	Western Energy Imbalance Market operated by CAISO
Y	
YELP	Yellowstone Energy Limited Partnership